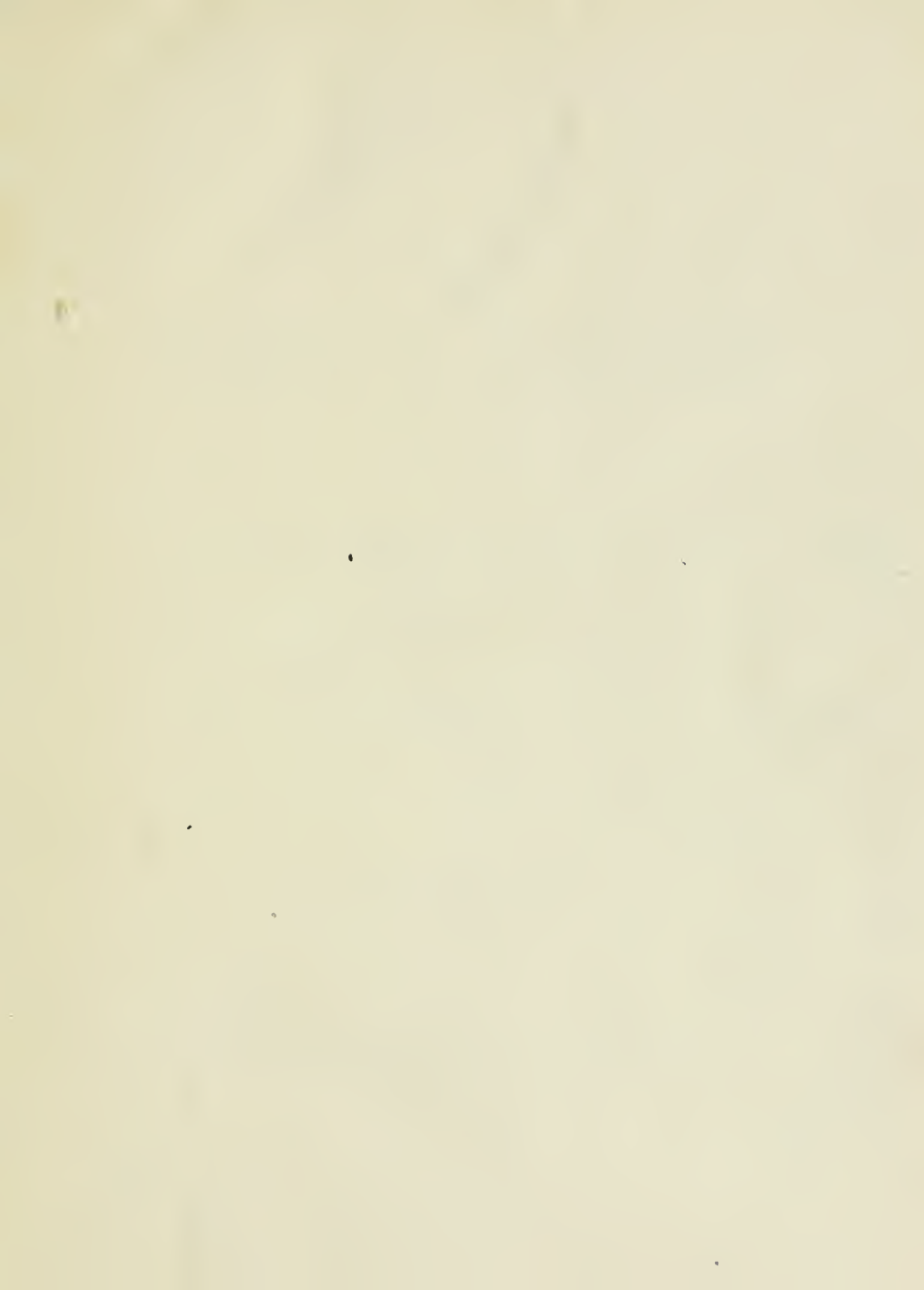




Digitized by the Internet Archive
in 2010 with funding from
University of Toronto

<http://www.archive.org/details/chemicalage09newy>



THE
CHEMICAL ENGINEER

A MONTHLY JOURNAL OF PRACTICAL, APPLIED AND
ANALYTICAL CHEMISTRY

VOLUME IX

JANUARY—JUNE, 1909

THE CHEMICAL ENGINEER PUBLISHING CO.
355 DEARBORN STREET
CHICAGO, ILL.

123942
29/8/12

INDEX.

Volume IX—Subject Index.

Acids, Air Compressor for Pumping	81
Allentown Portland Cement Company, Description of the Plant	128
Alloy, New Methods of Analysis	4
Alumina, A Direct Volumetric Method for the Determination of	115
Alumina, The Use of—in Metallurgy	170
Alumina in Phosphate Rock	107
American Chemical Society	50
Ammonia Process, The Manufacture of Soda Ash by the	93
Analysis, New Methods of Chemical	9
Analytical Chemistry, The Future of	23
Analyzed Chemicals	146
Atomic Weights, International	49
Baker Chemical Co., Plant of J. T.—Phillipsburg, N. J.	58
Belt Lacing Leather	102
Bisulphite of Soda, The Manufacture of	55
Blast Furnace Slag	13
Blast Lamp, Natural Draft	8
Boiler Corrosion, Air a Cause of	143
Boiler Tests, The Examination of Flue Gases in	27
Book Reviews	87, 121, 195
Brass, Making	24
Bromine, Manufacture in Ohio	49
Bronzes, On High Tension	30
Burette Clamp, A New	22
Calcium Sulphate, The Behavior of—at Elevated Temperatures with Some Fluxes	152
Calcium Phosphate, The Commercial Manufacture of Amorphous	13
Camphor, The Chemistry of Synthetic	164
Casein, Uses of	113
Cement, New—for Sea Water	138
Cement Plant, A Modern	157
Chemical Calendar, A	196
Chemical Engineering, The Elements of—(Conveying Materials)	17
Chemical Engineering, Apparatus, Exhibit of—at the Pittsburg Meeting of the American Institute of Chemical Engineers	35
Chemical Engineers, First Annual Meeting of the American Institute of	24
Chemical Factories, Reinforced Concrete for	159
Chemical Manufacturer, Some Problems for the	85
Chemical Societies	24, 50, 87, 120, 159, 194
Chemical Treatment, The Mechanical Preparation of Solids for—Grinding	171
Chromium, Determination of Vanadium, Molybdenum—and Nickel in Steel	47
Cobalt, Separation and Estimation of—and Nickel	19
Coke Oven, The Bee-Hive—as a Power Plant	178
Combustion	52
Combustion, Methods of	193
Compressor, Air—for Pumping Acids	81
Concrete, Effect of Temperature on	138
Concrete Buildings for Explosive Factories	167
Concrete Surfaces, Preparing for Painting	156
Condensed Battery, An Improved—for Nitric Acid	72
Conveying Materials, The Elements of Chemical Engineering	17
Copper, "Hypo" Method for	11
Copper, New Volumetric Method for	12
Correspondence	52, 88, 122, 160
Electric Furnace, The—Reduction of Iron Ore	175
Electrolysis, Experiments on the—of Reinforced Concrete	168
Emerson Fuel Calorimeter, The	113
Enamelling, Iron for	167
Exhibit of Chemical Engineering Apparatus at the Pittsburg Meeting of The American Institute of Chemical Engineers	75
Explosive Factories, Concrete Buildings for	167
Ferrosilicon Explosions	106
Flue Gases, The Examination of—in Boiler Tests	27
Food, The Detection of Preservatives in	141
Free Lime in Portland Cement	193
Fuels, Manufacture of	193
Fuel Economy, in the Metallurgical Industries	193
Gas Calculations, Some Formulae and Tables for—in the Contact Process for Sulphuric Acid	91
Gas Generator, A Simple	192
Gases Resulting From the Use of High Explosives	185

Gibbs, Wolcott	26
Granite, Action of Sulphuric Acid on	166
Grinding, The Mechanical Preparation of Solids for Chemical Treatment	171
Halogens, Determination of the—in Organic Compounds	115
High Explosives, Gases Resulting From the Use of	185
Hunicke, Henry August	159
Incubator, An Electrically Heated	115
Incx to Articles on Applied Chemistry (opposite)	52, 89, 124, 160, 197
Industrial and Plant News	31
Industrial Furnaces, The Use of Pulverized Fuel for Heating	13
Iron, A Separation of—from Manganese	46
Iron, The Standardization of Potassium Permanganate Solution and Its Subsequent Use in Titrating	167
Iron for Enamelling	167
Iron, A Study of the Methods for the Determination of—and Alumina in Phosphate Rock	175
Iron Ore, The Electric Furnace Reduction of	149
Iron Ore, Fine—in the Rotary Kiln	143
Kilns, Big	121
Lead Chromate, The Change of Color of	9
Magnesium, Volumetric Estimation of	13
Manganese, A Separation of Iron from	14
Measuring Color, An Instrument for	65
Measuring, Apparatus for Weighing and—Solids, Liquids and Gases	19
Mineral Oil, New Test for	47
Molybdenum, Determination of Vanadium, —, Chromium and Nickel in Steel	157
Mortar Materials, The Development of	71
Nitric Acid, An Improved Condensing Battery for	10
Nickel, Rapid Estimation of—in Presence of Cobalt, Iron, Zinc, Manganese, Aluminum, Chromium, Uranium, Magnesium and the Alkaline-earth Metals	114
Nickel, The Quantitative Determination of—With Dymethylglyoxime as Applied to Various Materials	10
Nickel, Determination of Vanadium, Molybdenum, Chromium and—in Steel	23, 49, 85, 117, 157, 193
Nickel, Separation and Estimation of Cobalt and	115
Notes and Comments	141
Organic Compounds, Determination of the Halogens in	7, 44, 83, 186
Packing, A New Bag and System of	156
Paints, The Valuation of	59
Painting, Preparing Concrete Surfaces for	12
Perkin Medal, Awarding of the	13
Petroleum Naphtha, Rapid Determination of—in Turpentine	11
Petroleum Oils, Quick Method for Calculating Caloric Power of	11
Phosphorus in Phosphor-Tin	11
Phosphor-Tin, Phosphorus in	107
Phosphate Rock, A Study of the Methods for the Determination of Iron and Alumina in	120
Plaster of Paris, The Manufacture of	1
Potassium, The Volumetric Estimation of—as Cobaltinitrite	46
Potassium Permanganate Solution, The Standardization of—and Its Subsequent Use in Titrating Iron	124
Portland Cement Industry, The Present Status and Technology of the	144
Portland Cement, Free Lime in	147
Portland Cement, Chemical Analysis of	178
Power Plant, The Bee-Hive Coke Oven as a	9
Preservatives, The Detection of—in Food	149
Producer Gas, Pulverized Coal vs. — as a Fuel for Nodulizing Fine Iron Ore in the Rotary Kiln	117
Proscribe and Prescribe	31
Pulverized Fuel, The Use of—for Heating Industrial Furnaces	149
Pulverized Coal vs. Producer Gas as a Fuel for Nodulizing Fine Iron Ore in the Rotary Kiln	26, 54, 125, 161, 197
Recent Inventions	139
Reinforced Concrete for Chemical Factories	9
Rosin Spirit, A Fuel Color Test for	149
Rotary Kiln, Pulverized Coal vs. Producer Gas as a Fuel for Nodulizing Fine Iron Ore in the	9
Rubber, Analysis of	43
Salt, Refining	155
Sampling, The Importance of	192
Silica, Separating Tungsten and	7
Silica, The Determination of—in Portland Cement	129
Silk, The Artificial Industry	37
Silundum	43
Smelter Fumes, Making Sulphuric Acid From	93
Smelter Fumes, Recovering Sulphur From	12
Soda Ash, The Manufacture of—by the Ammonia Process	96
Sodium Hydroxide	
Soluble Glass, Its Manufacture, Properties and Uses	

Specific Gravity Balance, A New	191
Specific Gravity Bottle, An Improved LeChâtelier	145
Spelter, The Rapid Determination of Iron and Lead in	5
Standard Solutions, Preparation of a Solution for Making—of Sodium Hydroxide	12
Steam Consumption, The Measurement of the Steam Consumption in an Open Cooking Vat	103
Steel, Determination of Vanadium, Molybdenum, Chromium and Nickel in	47
Sulphite Pulp, Chemical Specifications for	165
Sulphur, Recovering from Smelter Fumes	43
Sulphur, Mining—in Louisiana	6
Sulphur Burner, An Improved	71
Sulphuric Acid, Action of—on Granite	165
Sulphuric Acid, Making—From Smelter Fumes	37
Sulphuric Acid, Some Formulae and Tables for Gas Calculations in the Contact Process for	91
Syphon, An Automatic Syphon	106
Tested Chemicals, Concerning	52
Tested Reagents	49
Tin Scrap, The Refining of—and Its Commercial Importance	181
Trade Literature	196
Tube Mill, A New Form of	79
Tungsten, Separating—and Silica	192
Turpentine, Rapid Determination of Petroleum Naphtha in	12
Uranium, Volumetric Determination of Vanadium and	11
Vanadium, Volumetric Determination of—and Uranium	11
Vanadium, Determination of—Molybdenum, Chromium and Nickel in Steel	47
Weighing and Measuring, Apparatus for—and—Solids, Liquids and Gases	65
Western Association of Chemists and Metallurgists	50
Western Chemical Manufacturing Co.	106
Wood Pulp Mills	106

AUTHORS' INDEX.

Bacon, Charles V., Action of Sulphuric Acid on Granite	166
Baker, J. T., Analyzed Chemicals	145
Blair, Andrew A., Determination of Vanadium, Molybdenum, Chromium and Nickel in Steel	47
Campbell, J. R., The Ice-Hive Coke Oven as a Power Plant	178
Darrah, William A., The Chemistry of Synthetic Camphor	163
Dumas, William C., A Study of the Methods for the Determination of Iron and Alumina in Phosphate Rocks	107
Eitner, W., Belt Lacing Leather	192
Fisher, E. H., The Standardization of Potassium Permanganate	46
Gano, Wm. P., The Determination of Silica in Portland Cement	7
Goldschmidt, Carl, The Refining of Tin Scrap and Its Commercial Importance	181
Hardinge, H. W., A New Form of Tube Mill	79
Hatchmann, A. P., Pulverized Coal vs. Producer Gas as a Fuel for Nodulizing Fine Iron Ores in the Rotary Kiln	148
Hofman, H. O., The Behavior of Calcium Sulphate at Elevated Temperatures with Some Fluxes	151
Hosker, R. R., Denver Works of the Western Chemical Manufacturing Company	60
Hunnicke, H. August, The Examination of Flue Gases in Boiler Tests	27
Kann, Robert, The Manufacture of Bisulphate of Soda	55
Kern, Sergius, On High Tension Bronzes	30
Lotka, Alfred H., Some Formulae and Tables for Gas Calculations in the Contact Process for Sulphuric Acid	91
Mason, William, The Manufacture of Soda Ash by the Ammonia Process	93
Meade, Richard K., Improved Specific Gravity Bottle	144
Meade, Richard K., The Use of Pulverized Fuel for Heating Industrial Furnaces	31
Meade, Richard K., The Valuation of Paints	82
Meade, Richard K., The Valuation of Paints	44
Meade, Richard K., The Valuation of Paints	1
Mostwisch, W., The Behavior of Calcium Sulphate at Elevated Temperatures with Some Fluxes	151
Munroe, Charles E., The Commercial Manufacture of Amorphous Calcium Phosphide	63
Offerhaus, C., The Standardization of Potassium Permanganate	46
Perry, J. P. H., Reinforced Concrete for Chemical Factories	138
Price, Wm. B., New Methods of Alloy Analysis	4
Quick, G. Everett, The Measurement of the Steam Consumption in an Open Cooking Vat	103
Reinhardt, Carl, An Automatic Syphon	106
Richards, Joseph W., The Electric Furnace Reduction of Iron Ore	175
Sadtler, S. P., Dr. Wolcott Gibbs	36
Sheridan, G. E., A Simple Gas Generator	192
Smith, Thorn, Some Experiments with the Ferric Oxide Contact Method of Making Sulphuric Acid from Smelter Fumes	37

The Chemical Engineer

PUBLISHED BY

The Chemical Engineer Publishing Co., 355 Dearborn St., Chicago

Vol. IX.

JANUARY 1909.

No. 1

THE VALUATION OF PAINTS.¹

By RICHARD K. MEADE.

Editor of the Chemical Engineer.

Paint consists of a pigment intimately mixed with and suspended in linseed oil (the vehicle). To this is usually added a drier and often such substances as barytes, gypsum, etc. The latter are termed by paint manufacturers "extenders." While these latter have no body, they nevertheless can not be considered entirely as adulterants, as they often add good qualities to the paint. Linseed oil after exposure to the air dries to a tough leathery film. This change is due to oxidation. If salts of manganese or lead are heated with the oil its drying properties are increased. Formerly linseed oil was boiled with manganese dioxide or lead peroxide. This, however, darkened the oil and now the practice is to add a "drier." This latter is formed by heating a small portion of the oil with the above oxides until they are dissolved.

Paint is as much an engineering material as steel, iron, wood, etc., since the permanence of a structure will largely depend upon its proper selection and use.

For engineering purposes paints may be divided into two classes: (1) those which are intended for the preservation of structural steel, etc., and (2) those intended for the ornamentation of buildings, etc. To a certain extent these two classes overlap; that is to say, that most woodwork is painted to protect it and most structures are improved in appearance by painting. Nevertheless, in painting a steel railroad bridge for example an engineer would give preference to that paint which would best protect the steel from rusting and corrosion rather than to that paint which would give it the most pleasing appearance. While on the other hand, in painting a frame depot, he would probably select the paint which best harmonized with surroundings and the architectural lines of the building.

Paints may be bought either dry or ready mixed. Dry paints are of course only pigments with possibly an extender added. They require mixing with oil, driers, etc., before use. It is now the usual practice to buy mixed paints, as in these the oil and pigment are more thoroughly mixed than can usually be obtained in the shop or in the field. The single exception to this is red lead, used for structural steel painting, which is mixed just before use as it hardens on standing, the proportions being 33 lbs. of red lead to a gallon of oil.

PIGMENT.

The coloring properties of a paint are due to the pigment which it contains. Pigments are substances chemically inert with, and insoluble in the liquid part of, the paint, which latter is technically called the "vehicle." The pigment is merely held in suspension in the fluid and when the latter dries the particles of the pigment are so thoroughly disseminated through the film formed, that they can not be detected individually except by the aid of a microscope. The pigment must, of course, be very finely ground and this fineness is usually tested by rubbing a sample of the pigment on a glass or porcelain plate with a palette knife or spatula, side by side with a standard sample, and then comparing the two. The list below gives the principal pigments and their properties.

WHITE PIGMENTS.

White Lead. 2PbCO_3 , PbH_2O_2 . Approximate composition = PbCO_3 , 60%; PbH_2O_2 , 31%. White lead made by the slow so-called Dutch process is to be preferred to that made by the quick process. White lead has great covering properties and to this it no doubt owes its popularity as a paint. Volumetrically considered it has greater hiding properties or body than any other white pigment, but gravimetrically considered it has less hiding property than any of the lighter paints. White lead should never be used where subject to hydrogen sulphur gases, as this darkens it by the formation of lead sulphide.

Sublimed White Lead.—Approximate composition, PbSO_4 , 75%; PbO , 20%, ZnO , 5%. Largely used in the United States, being obtained from the sublimation of galena. It is very valuable as a ship's paint owing to its hardness of drying and imperviousness of film.

Standard Zinc Lead White.—Approximate Composition, PbSO_4 , 50%; ZnO , 50%, usually contains from a trace to 1% ZnSO_4 . Is made from low-grade complex ores, at Leadville, Colo.

Zinc Oxide.— ZnO . Zinc oxide dries, but dries to a hard, brittle and vitreous surface; hence it is used in enamel paints, and also mixed with white lead to correct the chalky appearance of the latter. Zinc oxide when used in mixed paints also helps to keep the heavier white lead or other lead pigment in suspension in the oil. Zinc oxide is not visibly affected by sulphur gases and hence may be used often where white lead can not be employed.

Lithophone.— $\text{ZnO} + \text{BaSO}_4$. Composition, ZnO , 25.8%; BaSO_4 , 74.8%. Lithophone is extremely fine in texture and brilliant white. It has the same tintorial power, but

¹In the preparation of this article, such works as Toch's "The Chemistry of Paint" and Hall's "The Chemistry of Paints and Paint Vehicles" have been freely drawn upon.

greater hiding properties than zinc oxide. It is not attacked by sulphur gases, etc.

RED PIGMENTS.

Oxide of Iron.— Fe_2O_3 . One of the most valuable paints for protecting structural steel and iron.

Venetian Red.— $\text{CaSO}_4 + \text{Fe}_2\text{O}_3$. Composition, Fe_2O_3 , 20%–40%; CaSO_4 , 60%–80%. Not so good as pure oxide of iron. In mixed paints containing water Venetian red tends to become hard in the package.

Indian Red.— $\text{Fe}_2\text{O}_3 + \text{SiO}_2$. Composition, Fe_2O_3 , 75%–90%; SiO_2 , 10%–25%. Is very fine grained.

Vermillion.—Red sulphide of mercury. Is darkened by light and eventually turned brown. It is now largely superseded by the para-nitraniline reds.

Para-Nitraniline Red.—Is cheaper and more durable than vermillion. White lead cannot be mixed with para-nitraniline as the former destroys and turns brown, the color of the latter. It has great tinctorial properties, five per cent being sufficient for most paint.

Red Lead.— Pb_3O_4 . Must be mixed with linseed oil just before using otherwise it forms a hard mass. For this reason is not used in mixed paints. Often used as a priming coat for structural steel, as it possesses excellent preservative qualities.

YELLOW PIGMENTS.

Burnt Ochre.—Composition Fe_2O_3 , 60%; clayey matter, 40%. Is much used for primers owing to its tendency to penetrate the wood, filling the pores. It is a permanent and very satisfactory pigment, although not so brilliant as chrome yellow.

Raw and Burnt Sienna.—Raw sienna contains more ferric oxide than ochre (often 70%), otherwise it is similar in composition to the former. Burnt sienna is made by calcining the raw sienna at a moderate heat until the combined water is driven off and the pigment has acquired the desired shade. The latter is reddish yellow and very transparent.

Chrome Yellow.— PbCrO_4 . Is made in a number of shades varying from light lemon yellow to very deep orange. The lighter shades are all produced by precipitating lead sulphate with a chromate in manufacturing the pigment. Hence lead sulphate found in this pigment is not an adulterant. Chrome yellow is permanent, except where exposed to sulphide fumes, minute traces of which detract from the brilliancy of the pigment.

BLUE PIGMENTS.

Prussian Blue (*Chinese Blue, Antwerp Blue, etc.*).— $\text{Fe}_4(\text{Fe}(\text{CN})_6)_3$. The color of this pigment is destroyed by heat and the fixed alkalis. It is a perfectly stable color if free from soluble salts, such as sulphates. A mixed paint made of Prussian blue and white lead changes color in the package, becoming green, due to reduction of the iron. When applied to an exterior surface, however, the pigment is converted to its original blue shade by oxidation.

Ultramarine.—This is an artificial imitation of the mineral *lapis-lazuli*, made by heating together in a closed vessel, aluminum silicate, sodium sulphate, soda, sulphur and charcoal. Approximate composition, SiO_2 , 50%; Al_2O_3 , 25%; Na_2S , 15%; S, 10%; H_2O , 3%. Ultramarine can

be used with zinc oxide, but not with corroded white lead. It should also not be used with chrome yellow or chrome green. It should not be used with lead driers, but a resinate or oleate of manganese drier may be employed.

GREEN PIGMENTS.

Chrome Green.—This pigment is a mixture of chrome yellow and Prussian blue. The shade varies with the proportions of the two. Remarks which apply to Prussian blue and Chrome yellow apply also to this pigment.

Chromium Oxide.— Cr_2O_3 . This is a permanent but not very brilliant green (olive), and is only used where an absolutely permanent green is desired.

BROWN PIGMENTS.

Raw and Burnt Umber.—Earthy pigments containing large percentages of MnO_2 and Fe_2O_3 . If the raw umber is calcined the burnt umber results. The burnt umber is of a "warmer" and darker color than the raw.

BLACK PIGMENTS.

Bone-black is made by calcining bones and contains about 20% carbon and 80% calcium phosphate, etc. It is the most intense of the black pigments. The value of bone black depends entirely upon its blackness and strength. It should not contain any oily matter, as this retards the drying of the paint made from it. It has weak tinting power, but is much used for carriage painting.

Carbon-black is cheaper than bone-black and has an extended use in the manufacture of black paints. It has great tinting properties, but streaks so badly and is so much inferior to lamp-black that it is seldom used for tinting. It should be free from oily matter.

Lamp-black is the condensed smoke of oil. It is very finely subdivided, which gives it great tinting powers. For this purpose it is much used and when employed with white lead and zinc oxide gives a clear bluish tone. It is always employed when clear tints are desired. It often contains oil and this retards the drying of the paint.

Graphite.—This is a mineral form of carbon. When used alone the paint film is too thin, and while appearing well, soon allows decomposition to take place under it. Graphite should therefore be mixed with red lead, ferric oxide, silica, etc., before applying. Graphite is largely used for painting structural steel and ships' bottoms, as it is not attacked by weather, sulphur fumes, etc.

EXTENDERS OR FILLERS.

These are nearly always used for mixed paints, as the paint is improved thereby. The principal extenders and their qualities are given below:

Silica.— SiO_2 . It should be free from grit. It is an excellent filler for iron paints and does not combine with either pigment or vehicle. It is the best of the extenders, as it possesses what is technically termed a tooth; that is, it presents a rough surface which facilitates repainting. As much as 35% of it can be used in a mixed paint.

Infusorial earth, a form of silica, is very light and is used to prevent the settling of the paint in the cans. China clay is a silicate of alumina, which is somewhat used in paint manufacture. It separates from the oil, however, and hence is not well suited to painting upright surface, as on these it runs. Silicate of magnesia is also employed in mixed paints, but is not a very satisfactory extender.

Barium Sulphate.— BaSO_4 . This is obtained in two forms, the artificial known as "*blanc fixe*" and the natural, *barytes*. Blanc-fixe is a fine amorphous powder and may be used in place of zinc white. It may compose 70% of a white pigment and 90-95% of a colored one. It increases the spreading of coarser colors. Barytes is much used with white lead, often as an adulterant. It, however, makes a white pigment more permanent and adds to the covering qualities of most paints. It is heavy and grinds poorly with oil. It also spreads badly and on this account, not more than 35% can be conveniently used in a house paint.

Calcium Carbonate, Whiting, CaCO_3 . Has no covering power, but is sometimes used in mixed paint in the proportion of 3-5% to neutralize any acid which may develop in the paint. This is particularly good practice in paints for metal. Whiting is also the solid component of *putty*. Calcium carbonate obtained as a by-product from the manufacture of soap always contains free lime. This forms a lime soap with the linseed oil causing the putty or paint to harden in the can.

Calcium Sulphate, Gypsum, CaSO_4 . The Pennsylvania Railroad allows 70% gypsum in its freight car color. It is soluble in water and is but faintly opaque.

Magnesium Carbonate, MgCO_3 , is used to some extent as a wood filler.

VEHICLES.

The principal oils used in paint manufacture are linseed oil, menhaden oil and Chinese wood oil (or Tung oil).

Linseed oil is obtained from flax-seed by extraction or subjection to pressure. It is obtained in three forms, raw oil, boiled oil and bleached oil. Cold pressed oil is lighter in color than the warm pressed. Boiled oil is made by heating the oil to about 250° F., adding a drier and keeping the mixture at this temperature for several hours. So-called "bunge" boiled oils are made by adding the drier to the raw oil without heating the latter. A properly boiled oil to which the proper amount of drier has been added should dry in 8 or 10 hours. Bleached oil is made by a number of processes; the most used of which consists in adding sulphuric acid to the oil and blowing air through. This causes the oil to become cloudy and contain small black clots. After filtering the oil is of a much lighter color than the raw oil and this oil is used for white paints.

Menhaden oil is obtained from the fish of that name and when fully refined it has no odor and is very light in color. Menhaden oil is usually prepared for paints by heating with litharge at 400° F. for ten hours, when it thickens and is reduced by naphtha. When so treated it is better than linseed oil for some purposes. It withstands high temperatures and light well and hence is used for smoke-stack paints. Raw Menhaden oil is also used with linseed to make roof and ship-deck paints, as it confers waterproofing properties upon the paint.

Chinese wood oil is made by cold pressure from the seeds of the tung tree (China.) It has for some time been extensively used for the manufacture of varnish. It ordinarily dries flat (presenting an appearance somewhat like ground glass) and so is not suited to paint manufacture, but it may by special treatment be made to dry like linseed

oil. It is recommended for paints to be used in damp places as it dries in a moist atmosphere. It is also a good floor paint as it can be washed. It is used in making enamel paints as it dries with a very hard glossy surface. It forms a drier when heated with red lead, manganese rosinate and manganese borate.

THINNERS.

The principal thinners are turpentine and benzine. Rosin-spirits, benzole (benzene) and wood turpentine are also used. Thinners add nothing to the actual value of the paint except to make it easier to apply, as the thinned paint is more readily brushed out. They should be used only when absolutely necessary, as the durability of the paint may be said to be inversely proportional to the amount of thinner used, consequently the less the better. Addition of a thinner to paint diminishes its body and allows it to be spread over a greater surface. Consequently the thickness of the paint film is reduced, and hence its wearing and protecting qualities.

Turpentine is manufactured by distilling pine resin. It is considered better than benzine for thinning paint for a number of reasons, chief of which are that it is not so inflammable, does not evaporate so fast, is a better solvent for many gums and makes the paint flow out more evenly than does benzine. Wood turpentine is not the same compound as spirit turpentine although resembling it somewhat. Wood turpentine is made by the destructive distillation of the tags (leaves), stumps, saw-dust, etc., of the pine. It has a bad odor which makes its employment in indoor paints disagreeable, otherwise it is very much like spirits of turpentine and costs about five cents less a gallon.

Benzine is produced from paraffin oil. It is cheaper than turpentine and is generally considered inferior to it. An exception to this is in paints to be applied by dipping the article into it. Here the rapid evaporation of the solvent helps to produce an even coat.

Benzole (benzene, solvent naphtha, etc.) is made from coal tar and is a powerful solvent for paints and varnishes. It is much used in asphalt paints and in coal-tar paints. It is said to be of advantage in paints to be used for priming purposes as it helps the bond between the wood and the paint. Owing to its solvent properties it should not be used for second coats as it is apt to attack the ground coat and produce a shriveled effect.

DRIERS.

There are two classes of driers, oil driers and resin or "Japan" driers.

Oil driers are all made by heating linseed oil to between 500 and 600° F. with a salt of lead or manganese until the product thickens, when it is thinned with turpentine, benzine or a mixture of both. Oil driers when spread out on a glass plate do not themselves dry rapidly.

Japan driers are made by incorporating metallic salts with resin or resin and linseed oil, and thinning the product with benzine or turpentine. Japan driers when spread on a glass plate dry quickly like a varnish. Oil driers are the better of the two classes of driers as they oxidize more slowly. Japan driers cannot be employed in connection with red lead unless the paint is to be used at once as the two react and the paint becomes spongy.

(To be continued.)

NEW METHODS OF ALLOY ANALYSIS.

By WM. B. PRICE.

*Chief Chemist, Scott & Mfg. Co., Waterbury, Conn.***The Rapid Determination of Nickel in German Silver, Watch Nickel, and Nickel Alloys.**

The method of estimating nickel by means of adding potassium cyanide to an ammoniacal solution of nickel containing silver iodide in suspension, so that the solution remained turbid until the nickel was all converted into the double cyanide of nickel and potassium; after which a single drop of the cyanide in excess cleared up the solution, was originally proposed by T. Moore, and modified by the writer for use in German silver, etc.

The following elements interfere with the method: Manganese, zinc, iron, aluminum, and especially copper, which owing to its forming cyanides would render the process valueless. Cobalt if present will be estimated as nickel.

The iron, aluminum, and zinc may be kept in solution so that they do not interfere by using organic acids, such as tartaric, citric, etc., or sodium pyrophosphate. The copper may be separated from the zinc, nickel, etc., by any of the well known methods.

C. M. Johnson¹ found that nickel could be determined in the presence of manganese by the use of a large amount of citric acid (24 grams citric acid to 1 gram of the alloy);—0.25 per cent of nickel being detected in the presence of 95 per cent of manganese. The writer has no experience with this method, as the amounts of manganese found in German silver rarely exceed .50 per cent and are determined simultaneously with the copper, by electrolysis.

The following analysis of a leaded German silver will illustrate the method:

Lead.—Dissolve one gram of the alloy in 5 c.c. of nitric acid (Sp. Gr. 1.42) in a glass evaporating dish, covered with a watch glass on a steam bath or hot plate. When action has ceased wash down watch glass, and add 2 c.c. of sulphuric acid (Sp. Gr. 1.84). Evaporate until white fumes are given off, take up in hot water, filter into a weighed platinum Gooch crucible, wash with a solution of distilled water, containing 10 c.c. of sulphuric acid (Sp. Gr. 1.84) and 10 c.c. of alcohol to the liter. Ignite for five minutes resting the crucible on a platinum crucible cover. Cool and weigh as PbSO_4 . $\text{PbSO}_4 \times 0.6820 = \text{Pb}$.

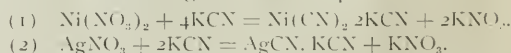
Provided the alloy contains no manganese it may be dissolved directly in 15 c.c. of nitric acid (Sp. Gr. 1.42) in a 200 c.c. electrolytic beaker, and the lead and copper deposited by electrolysis. Dilute the solution to 150 c.c. with distilled water, and electrolyze with a current of N. D.₁₀₀—1—1.5 amperes and 1.4 volts. The lead will be all precipitated in the course of an hour upon the anode, and the copper will be deposited at the same time on the cathode. The lead separates first, and the copper more slowly. When the lead is fully precipitated wash with water and alcohol and dry for fifteen minutes at a temperature from 200°—230° C. Cool and weigh $\text{PbO}_2 \times 0.8643 = \text{Pb}$.

Copper.—Neutralize the solution with ammonia and add

5 c.c. of nitric acid (Sp. Gr. 1.42) and 2 c.c. sulphuric acid (Sp. Gr. 1.84) and electrolyze with a current N. D.₁₀₀—0.5 ampere and 2 volts, until copper is fully precipitated. Wash with water and alcohol, dry, cool and weigh. Increased weight is metallic copper.

Copper and Manganese.—In this case it is assumed that manganese is present. To the filtrate from the lead sulphate add 2 c.c. of dilute nitric acid (1-1). If more than 3 or 4 per cent of nitric acid is present the manganese will not all be precipitated on the anode, but will remain in solution, and a red color will appear at the anode due to the formation of permanganic acid. Electrolyze with a current of N. D.₁₀₀—0.5 ampere and 2.5 volts. The manganese will be deposited upon the anode as dioxide and the copper will be deposited at the same time on the cathode. The electrodes used by the writer consist of two cylinders, one fitting inside the other. Wash the manganese dioxide on the anode with water and alcohol, dry and ignite. The dioxide will be converted into $\text{Mn}_2\text{O}_3 \times .7205 = \text{Mn}$. Wash the copper on the cathode with water and alcohol, dry, cool, and weigh. The increase in weight is metallic copper.

Nickel.—After removal of copper and manganese transfer the solution containing the iron, nickel and zinc to a 400-c.c. beaker. Add from 3 to 4 grams of ammonium chloride and then 50 to 75 c.c. of a solution of sodium pyrophosphate, containing from 10 to 15 grams of Merck's pure crystals. Make up this solution just before using, and use a quantity depending upon the amount of zinc present. Neutralize with ammonia and then add enough to make the solution only slightly but yet distinctly alkaline. A large excess of ammonia will hinder or entirely prevent the reaction. Cool and do not let temperature of the solution get much above 20° C., or the result will be irregular. Add 2 c.c. of a 10 per cent solution of potassium iodide and titrate with a standard solution of potassium cyanide containing silver nitrate, until the white cloud caused by the formation of silver iodide has entirely disappeared and one drop of the cyanide causes a clear solution. This is the end point, which is very sharp and distinct. The following reactions take place:



The turbid white cloud in the solution is caused by the precipitate of silver iodide which is almost insoluble in weak ammonia and this turbidity will increase up to the point where the formation of the double cyanide of nickel and potassium is complete; when the slightest excess of cyanide will clear up the solution.

The zinc is usually determined by difference and the iron in a separate sample as follows: Take one gram of the alloy, dissolve it in 10 c.c. of nitric acid (Sp. Gr. 1.42) in a 250-c.c. beaker; then, after solution is complete, add 10 c.c. of hydrochloric acid (Sp. Gr. 1.10) and 7 grams of ammonium chloride, dilute with water to 100 c.c. and heat to boiling, precipitate with ammonia, filter, wash with hot water, place a 300-c.c. flask containing 5 grams of C. P. zinc under the funnel and dissolve the ferric hydroxide with a hot solution of 10 c.c. hydrochloric acid

¹Jour. Amer. Chem. Soc., 5, 1201, 1907.

(Sp. Gr. 1.19) and 20 c.c. water. When action has nearly ceased, add a solution of 10 c.c. sulphuric acid (Sp. Gr. 1.84) and 20 c.c. water, which will dissolve the remainder of the zinc, and insure a sharp end point with the potassium permanganate. When zinc is all dissolved, fill the flask up to the neck with cold water, and cool under the tap to room temperature. Transfer to a 400-c.c. beaker and titrate with standard solution of potassium permanganate. If it is considered necessary to determine zinc other than by difference, the zinc and nickel can be separated in the following manner. Evaporate the solution left after removal of copper by electrolysis (in order to save time the copper may be precipitated and separated from the zinc, nickel, etc., by metallic aluminum, hydrogen sulphide, or any other of the well-known methods) to small bulk and nearly neutralize with sodium hydroxide. Pour the solution containing zinc, iron and nickel slowly with constant stirring into 60 c.c. of a ten per cent solution of sodium hydroxide, then add 60 c.c. of distilled water, and filter. Dissolve precipitate in as little hydrochloric acid as possible, and repeat precipitation with 60 c.c. of ten per cent solution of sodium hydroxide. Combine the filtrates, which will contain the zinc. Dissolve the nickel and ferric hydroxide in dilute nitric acid, then add 2 c.c. of concentrated sulphuric acid.

The presence of the sulphuric acid insures a sharper end reaction with the potassium cyanide solution. Add ammonium chloride, sodium pyrophosphate, etc., and titrate with standard solution of potassium cyanide as described before.

Owing to the fact that zinc is not present in this case, it is only necessary to add about one-quarter of the amount of ammonium chloride and sodium pyrophosphate or just enough to hold the iron in solution. Acidify the combined filtrates containing the zinc with formic acid, heat to about 80° C. and pass in hydrogen sulphide. As soon as the zinc is all precipitated, filter and wash with hot water. Dissolve the zinc sulphide in hydrochloric acid and boil to expel hydrogen sulphide. Make faintly alkaline with ammonia, then faintly acidify with hydrochloric acid and then add 3 c.c. in excess of concentrated hydrochloric acid. Dilute to 250 c.c. and heat to nearly boiling and titrate with a standard solution of ferrocyanide, until one drop of the solution tested on a porcelain plate with a drop of a 15 per cent solution of uranium acetate shows a brown tinge.

Reagents.—Standard solution of potassium cyanide containing silver nitrate. This solution should contain 25 grams of pure potassium cyanide and 1.25 grams of silver nitrate to the litre. Many of the commercial cyanides contain sulphur which causes a darkening of the solution when titrating, due to the formation of silver sulphide. If pure cyanide is not obtainable, the sulphur impurity may be removed by thoroughly agitating the cyanide solution with oxide of bismuth. Potassium iodide 10 per cent solution. Sodium pyrophosphate, Merck's pure crystals. Ammonium chloride, the C. P. salt.

Standardization.—The solution is standardized on a solution of known nickel contents. The writer uses crystallized, C. P. nickel sulphate. Dissolve about 4 grams in a

400-c.c. beaker. As all nickel sulphate contains iron as an impurity, it must be removed before electrolyzing solution for nickel. After removal of iron transfer solution to a carefully graduated 500-c.c. flask. Dilute to the mark with water and after thoroughly mixing the solution remove two 50-c.c. portions with a pipette, transfer to two 200-c.c. electrolytic beakers. Add 2 c.c. sulphuric acid (Sp. Gr. 1.84), neutralize with ammonia, add 40 c.c. of ammonia (Sp. Gr. 0.96). Electrolyze with a current of $ND_{100} = .5$ ampere and 2.5 volts.

After the nickel is all precipitated, wash with water and alcohol, dry and cool. The increase in weight gives the actual nickel contained in 50 c.c. of solution. A solution of this strength should contain about .1 gram of nickel and should contain enough free acid to prevent the formation of any precipitate on the addition of ammonia to alkaline reaction. If a precipitate forms, add a little ammonium chloride and it will clear up.

Take 50 c.c. of the solution in a pipette and transfer to a 400-c.c. beaker, dilute to 200 c.c., make slightly alkaline with ammonia, add a few drops of potassium iodide and titrate with potassium cyanide solution, adding it slowly, until one drop causes the white cloud to entirely disappear.

Example.—If 50 c.c. of the solution contained 0.0905 grams of nickel and it took 20.3 c.c. of potassium cyanide to produce a clear solution, then 1 c.c. of potassium cyanide would be equivalent to 0.00445 grams of nickel. It is surprising that this method has not come into more general use, combining as it does extreme accuracy and great rapidity with ease of manipulation. After the removal of the copper, the total time consumed in determining the nickel should not exceed twenty-five minutes. When one considers that it enables the operator to dispense with the usual tedious separation of zinc and nickel the superiority of the method in the analysis of German silver is very actual.

Sample No. 1—Leaded German Silver.

Lead as sulphate.....	.78
Copper by electrolysis.....	60.80
Manganese by electrolysis.....	.22
Nickel titrated with KCN.....	17.78
Iron titrated with $KMnO_4$	.18
Zinc titrated with $K_4Fe(CN)_6$	20.11
Total	99.96

Sample No. 2—Cupro-Nickel.

Copper by electrolysis.....	83.45
Manganese by electrolysis.....	.25
Nickel titrated with KCN.....	16.21
Nickel titrated with $KMnO_4$	.08
Total	99.99

The Rapid Determination of Iron and Lead in Spelter.

In sampling spelter it is customary to take three or four slabs from each car of the shipment. Two holes are drilled in each slab about four inches from the ends in order to allow for the segregation of lead in the slab.

The drill should be run at a slow speed and with a slow feed in order to obtain drilling which will dissolve readily in the acids used. Pass a magnet through the drilling before weighing in order to remove any particles of iron that may have become mixed with the spelter. Failure to do this is often the cause of annoying discrepancies in the results of different chemists.

Every shipment of spelter is analyzed for iron and lead, and in those brands that are known to contain cadmium, this element is also determined. The method commonly employed is to dissolve the zinc either in a mixture of sulphuric acid and water, or hydrochloric acid and water. In either case zinc only goes into solution, the other metals, with the exception of arsenic and antimony, being left as spongy masses. The sample is generally weighed in the afternoon and allowed to stand over night at ordinary temperatures until all action has practically ceased. It is then filtered and washed with hot water. The filtrate contains the iron.

The solution is boiled, then cooled to room temperature and titrated with a standard solution of potassium permanganate. In case the iron has become oxidized to the ferric state it is reduced by five grams of C. P. zinc in which the amount of iron is known and deducted from the total iron found. The residue on the filter contains the lead, which is digested with nitric acid. Sulphuric acid is then added and the solution evaporated to fumes and the lead determined either as lead sulphate, or sodium acetate and acetic acid are added and the solution titrated with a standard solution of ammonium molybdate. Owing to an increasing demand for greater speed and higher accuracy the following rapid method was devised by the writer. It has been in use for some little time, and has given such good satisfaction that the writer thought it might prove helpful to others engaged in the same line of work.

Lead.—Weigh out five grams of spelter into a 400-c.c. beaker, add a few c.c. of water, cover with a watch glass and dissolve in 20 c.c. nitric acid (Sp. Gr. 1.41-1.42), adding it 10 c.c. at a time on account of the violent action. When action has ceased and the zinc is dissolved, which will take only two or three minutes, wash the watch glass and sides of the beaker with distilled water and transfer solution to a 200-c.c. electrolytic beaker, and dilute with distilled water. The volume of the electrolyte should be 150 c.c. and its temperature 50°-60°. Electrolyze with a current of $NI_{lim} = 1 - 1.5$ amperes and 2.5 volts.

The anodes are platinum cylinders 2 inches long and one inch wide and having a stem of heavy wire 4 inches above the cylinder, making the total height 6 inches. To obtain the best results the anodes should be roughened with the sand blast. The cathodes are heavy platinum wires, 6 inches long, with spirals at the ends. In the course of an hour all the lead will have been precipitated upon the anode. Wash the latter without interrupting the current. Wash with water and alcohol and dry for fifteen minutes at 200°-230° C. If the deposit is not dried for this length of time and at the above temperature it will weigh too much, due probably to included water, which is expelled with difficulty.

The writer has found, as did Prof. E. F. Smith, that the factor to multiply the dioxide by to get the lead value should be .8643 instead of .866. Any zinc that may form on the cathode can be disregarded, as it has no effect upon the deposit of PbO_2 on the anode. This can be entirely avoided by using a small cylinder 2 inches long and $\frac{1}{2}$ inch wide as a cathode instead of the heavy platinum wire. The PbO_2 deposit can be readily removed by covering the anode with a solution of dilute nitric acid and inserting a rod of copper.

Iron.—Weigh 5 grams of spelter into a 10-oz. flask. Treat with a mixture of 10 c.c. of strong hydrochloric acid and 20 c.c. of distilled water. When strong action has ceased and a drop of the solution on a porcelain plate gives no red tinge with a drop of potassium thiocyanate solution, add gradually a mixture of 10 c.c. strong sulphuric acid and 20 c.c. distilled water. This should dissolve most of the zinc remaining and secure a sharp end point with the potassium permanganate. When the zinc is all dissolved, fill the flask to the neck with cold distilled water and cool to room temperature. Filter off the black residue, which contains lead, using a plaited filter, on which it is advisable to sprinkle some granulated zinc to prevent oxidation. If the lead were not filtered off it would consume permanganate, and cause trouble by increasing the percentage of iron. Dilute the filtrate to 400 c.c. Titrate the filtrate with a standard solution of potassium permanganate containing 1.118 grams of $KMnO_4$ per liter until a very faint permanent pink color is obtained. One c.c. of this solution will oxidize .002 grams of iron and on the basis of five grams taken 1 c.c. = .01 per cent of iron. Its exact values may be found by standardizing in the usual way with metallic iron. The complete analysis of the spelter for lead and iron should not take over an hour and a half, and the number of the determinations possible is only the number of units at hand.

MINING SULPHUR IN LOUISIANA.

The largest sulphur mines in the world are located at a place called Sulphur, on the Southern Pacific railway in the southwest corner of Louisiana. This sulphur is mined in an original manner and different from any other mine. Large pipes are sunk to where the mineral lies, then steam is turned on, the sulphur melted and pumped up into tanks in a liquid state and then allowed to cool. When gathered into the tanks it is 98 per cent pure.—L. Peavey in *Mining Science*.

Cryolite is used in the manufacture of sodium salts, the manufacture of certain special kinds of porcelain and glass and as a flux in aluminum smelting. For the last purpose, however, the demand has lately been greatly diminished by the substitution of a product derived from fluorspar. By far the major portion of the cryolite imported into the United States is employed for the manufacture of sodium salts. The business is entirely in the hands of the Pennsylvania Salt Manufacturing Company of Natrona, Pa.

THE DETERMINATION OF SILICA IN PORTLAND CEMENT.

By WILLIAM P. GANO.

Chief Chemist, Pennsylvania Cement Co., Bath, Pa.

The following experiments upon the determination of silica in Portland cement may prove of interest to the readers of THE CHEMICAL ENGINEER who are engaged in this line of work. They do not represent any very original ideas, but merely show the errors to be met with in this determination as usually carried out.

The first point considered was the error met with in determining silica by a single evaporation and baking the residue at 100°-110° C. for one hour. It was found that if the sample was treated in substantially the same manner each time—viz., dissolved in 20 c.c. of dilute hydrochloric acid (1:4), evaporated to dryness on the water bath and the residue baked for one hour at 100°-110° C. in an air-bath—the error would be practically constant for all samples of Portland cement. The following determinations illustrate this point:

No.	% SiO ₂ One Evaporation.	% SiO ₂ Two Evaporations.	Error % SiO ₂ .
931	20.28	20.60	0.32
932	20.10	20.40	0.30
934	20.62	20.92	0.30
938	20.82	21.12	0.30
939	20.60	21.00	0.34
Average error			0.31

A number of determinations were also made to ascertain the amount of silica left in soluble form by one evaporation and baking at 100° to 110° C. with shales and limestones. In the former case the sample (0.5 gram) was fused with sodium carbonate (5 grams) and the fusion dissolved in dilute hydrochloric acid (1:4); the solution evaporated to dryness and the residue baked for one hour at 100°-110° C. in an air-bath. With cement-rock (argillaceous limestone) the sample was heated for ten minutes with an equal weight of sodium carbonate, first over a burner and then over a blast lamp, the sintered mass dissolved in acid, evaporated and baked as above. A few of the results follow:

-Sample of—	% SiO ₂ One Evap'n.	% SiO ₂ Two Evap'ns.	Error % SiO ₂ .
Shale	68.36	68.90	0.54
Shale	61.32	61.84	0.52
Cement-rock ...	13.66	13.90	0.24
Cement-rock ...	12.88	13.12	0.24
Cement-rock ...	12.76	13.04	0.28
Cement-rock ...	12.84	13.12	0.28
Average error for shale			0.56
Average error for cement-rock			0.26

It will be seen that the error where the silica is dehydrated by baking in an air-bath at 100°-110° C. for one hour is, in the case of Portland cement, approximately 1.5% of the total silica present, in the case of cement-rock 2%, and in the case of the shale 1.2%. Where one evaporation is used, therefore, and the sample is baked at 100°-110° C. for one hour, the silica may be corrected by the use of the formula—

True % SiO₂ = % SiO₂ found by one evaporation × 1.015.

In the case of the cement No. 939 this would give 20.66 × 1.015 = 20.97% instead of the 21.00% actually found by two evaporations.

With respect to the impurities in the silica, a large number of determinations made by the writer show that where Portland cement is attacked by dilute hydrochloric acid (1:4) and is almost completely soluble in this, leaving only a slight floatant residue, the impurities amount to almost exactly 1.5 per cent of the weight of silica found. In other words, the impurities in a silica from cement weighing 0.1012 will be 0.0015 and in one from cement-rock weighing 0.0675 will be 0.0010. Expressed as a formula the correction due to impurities will be:

True % SiO₂ = % SiO₂ found by two evaporations — (% SiO₂ × 1.015).

It will be seen that these two corrections balance each other as Meade contends on page 178 of his work, "Portland Cement."

With respect to the iron and alumina determination, where one and two evaporations are made, the following results do not seem to indicate that the silica which remains in the filtrate is all precipitated here or indeed that any considerable portion of it is thrown down with the iron and alumina:

	% Fe ₂ O ₃ + Al ₂ O ₃ One Evap'n for SiO ₂ .	% Fe ₂ O ₃ + Al ₂ O ₃ Two Evap'ns for SiO ₂ .	Error % Fe ₂ O ₃ + Al ₂ O ₃ .
Cement	10.02	10.00	0.02
Cement	10.38	10.36	0.02
Cement	9.90	9.84	0.06
Cement	10.14	10.12	0.02
Cement-rock ...	7.00	6.98	0.02
Cement-rock ...	6.40	6.32	0.08
Cement-rock ...	6.22	6.12	0.10

The impurities (SiO₂) found in the iron and alumina precipitate in these determinations amounted to 0.0006 to 0.0008 grams or a correction of approximately 1% of the total iron and alumina present. In making these iron determinations, ammonia free from SiO₂, kept in wax bottles, was used. In the case of the iron and alumina, therefore, the correction to be applied when only one evaporation and no purification of precipitates are made may be expressed as follows:

True % Fe₂O₃ + Al₂O₃ = (% Fe₂O₃ + Al₂O₃ found) + (% SiO₂ found × 0.015) — (% Fe₂O₃ + Al₂O₃) × 0.01.

The true silica may be found by use of the formula—

True % SiO₂ = % SiO₂ found + (% Fe₂O₃ + Al₂O₃) × 0.01.

These formulae, of course, only apply to cases where the silica and the iron and alumina are determined by the methods outlined above. Applying them to a cement which gave on analysis: Silica, 22.10%; iron oxide and alumina, 8.74%, we have, Silica = 22.10 + 8.74 × 0.01 = 22.19 and iron oxide and alumina = 8.74 + 22.10 × 0.015 = 8.74 × 0.01 = 8.98. On analysis using two evaporations and purifying both the silica and the iron and alumina precipitates, the silica was found to be 22.22 and the iron oxide and

alumina 10.00. It will be seen that the error in the case of the silica is much less than is that in the case of the iron and alumina. Neither, however, are considerable enough to make a technical analysis untrustworthy.

The subject of the use of porcelain and glass vessels for the determination of silica was also investigated. Kortwright in this journal (see *CHEMICAL ENGINEER* Vol. V, p. 19) showed the error in silica due to the use of porcelain dishes, and the writer's conclusions bear out his contentions. The following determinations made in glass dishes, porcelain dishes and platinum dishes show the errors to be met with from the use of the two former in cement analysis:

Per Cent of Silica			
	Glass Dish.	Porc. Dish.	Plat. Dish.
Cement	21.12	21.00	21.22
Cement	20.48	20.34	20.56
Cement	20.82	20.68	20.96
Cement-rock . . .	12.84	12.72	13.12
Cement-rock . . .	12.18	12.00	12.28

It will be seen from the above that loss of silica occasioned by the use of porcelain dishes is much greater than that caused by making only one evaporation to dehydrate silica and also that glass dishes are better for this purpose than are porcelain. In these determinations, old porcelain and glass dishes were used, as it was suggested that the amount of silica deposited by one analysis might be rubbed or dissolved off in the next. The error seemed to be the same, however, whether new or old dishes were used.

In the standard scheme of analysis recommended by the New York Section of the Society of Chemical Industry, occurs the following: "One half gram of finely powdered substance is to be weighed out. . . . It is then transferred to an evaporating dish, preferably of platinum, for the sake of *celerity* in evaporation," etc. As a matter of fact, celerity of evaporation has very little to recommend platinum in comparison with the need of its use where accuracy is desired. Experiments showed platinum to evaporate the samples two minutes quicker than porcelain and six minutes quicker than glass, while the amount of silica which would remain on the sides of a glass dish would amount to as much as that recovered by the second evaporation. So that the real need of the platinum dish is for accuracy and not celerity.

Garnet is a silicate of varying composition and of a hardness a little less than quartz. Pure crystallized garnet is a gem of great value. Commercial garnet may be either massive or crystalline. It is used in the manufacture of garnet paper, an abrasive used in making shoes. Lump garnet is worth \$35 per ton, while the ground product varies from \$45 to \$60 per ton at New York. Garnet is found in Connecticut, New York, Pennsylvania, Georgia, North Carolina and in the Rocky Mountain states.

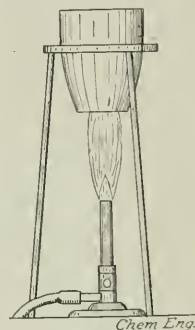
The simplest way to treat waste sulphuric acid in a brass plant, states a writer on copper and brass, is to evaporate it to one-half its bulk, using waste heat from the furnace, which crystallizes out most of the copper sulphate.

NATURAL DRAFT BLAST LAMP.

Written for the *CHEMICAL ENGINEER*.

The accompanying illustration shows a simple method of converting an ordinary Bunsen burner into a blast lamp. The arrangement consists of a tripod, such as can be purchased at any chemical supply house, or even made by a local blacksmith. The ring of the tripod should be about $2\frac{7}{8}$ inches inside diameter, $\frac{1}{2}$ inch wide, and about $\frac{1}{4}$ inch thick. The ring should stand about 10 inches from the table top. Into this ring is set a No. 20 fire-clay crucible (Denver Fire Clay Co.), from which the bottom has been cut, and under it is placed an ordinary Bunsen burner so that the flame passes up through the center of the crucible as nearly as possible. The crucible is held in the ring by the taper of the sides.

A triangle is placed on top of the crucible, when the apparatus is ready for use. When the gas is turned on and the platinum crucible has attained a red heat, the full force of the gas and air can be turned on. The pressure of the gas together with the draft of air passing through this miniature chimney, due to the heat, will create a roar



Natural Draft Blast Lamp.

and an intense heat. The latter may be increased by placing another fire-clay crucible, cut out at the bottom like the first, directly on top of the one in the tripod, with the large end down. The principal factor in producing a blast is the distance between the top of the burner and the bottom of the crucible. This point can easily be ascertained by raising and lowering the burner until results are obtained. The legs of the tripod can then be cut off so that the crucible will be held the proper distance from the burner top. The writer has used this blast lamp for 14 years in all classes of work where very high temperatures are necessary, such as in the analysis of clays, lime, alumina, bauxite, and various minerals of this class.

Ferro-molybdenum is sold per pound of pure molybdenum contained, regardless of the percentage of other material. Thus if a pound of 80 per cent ferro-molybdenum is purchased, $1\frac{1}{4}$ pounds of the alloy will be received. A typical analysis, the units of molybdenum only guaranteed, is as follows: Molybdenum, 79.15 per cent; iron, 17.55 per cent; carbon, 3.24 per cent; phosphorus, 0.028 per cent; sulphur, 0.021 per cent.

NEW METHODS OF CHEMICAL ANALYSES.

A NEW COLOR TEST FOR ROSIN SPIRIT.

C. Grimaldi describes in the *Chem. Zeit.*, Vol. xxxi., page 1145, a new test for the detection of rosin spirit in turpentine, camphor oil, mineral oil, etc. This test depends upon the fact that that portion of rosin spirit which boils at a temperature of 170° C. gives an emerald green color when heated with hydrochloric acid and zinc. The sample of the suspected oil is distilled and that portion which passes over at 170° C. is heated with an equal portion of concentrated hydrochloric acid and a small piece of zinc for five minutes in a boiling water bath, shaking the mixture frequently during the heating. If rosin oil is present, emerald green color forms.

VOLUMETRIC ESTIMATION OF MAGNESIUM.

L. Rosenthaler proposes the following method for the volumetric estimation of magnesium in *Zeit. anal. Chem.*, Vol. xlv., page 714, depending upon the precipitation in an ammoniacal solution of the magnesium by an excess of standard potassium hydrogen arsenate solution. The details of the method are as follows: To the magnesium solution in a graduated flask a measured excess of the standard solution of potassium hydrogen arsenate is added and the mixture diluted to a known volume with 10 per cent ammonia. After three hours, the solution is filtered through a dry filter and a definite quantity of the filtrate is evaporated to dryness on a water bath. The residue is taken up in as little water as possible and the solution poured into a stoppered flask. The dish in which the evaporation was conducted is rinsed with a cold mixture of equal parts of sulphuric acid and water, the rinsings being also added to the flask. A concentrated potassium iodide solution is now added to the liquid in the flask. This usually forms a precipitate which is to be dissolved by adding just sufficient water. After standing for 15 minutes, the liberated iodide is titrated with thiosulphate solution. The potassium hydrogen arsenate solution should contain about 9 grams of salt to the litre, and be standardized against the thiosulphate solution.

THE VOLUMETRIC ESTIMATION OF POTASSIUM AS COBALTNITRITE.

W. A. Drushel proposes the following method for the volumetric estimation of potassium as cobaltinitrite. The details of his method are to be found in *Zeit. anorg. Chem.*, Vol. xlv., page 223, and are as follows: 10 grams of the sample are boiled for 30 minutes with 300 cc. of water and then made slightly alkaline with ammonia, sufficient ammonium oxalate is next added to precipitate all the calcium. The contents of the flask are made up to 500 cc., mixed and filtered; 50 cc. of this filtrate is evaporated to 25 cc. and one cc. of dilute sulphuric acid (1:1) is then added and the evaporation carried to complete dryness. The residue is cautiously ignited and the potassium sulphate dissolved in hot water. The solution so obtained is treated with a fairly large excess of an acetic acid solution of sodium cobaltinitrite, and evaporated to pasty consistency on the water-bath. The residue is cooled, treated with 50 to 100 cc. of cold water to dissolve the excess of the cobaltinitrite and allowed to stand. The precipitate is

then collected on an asbestos filter, and washed with cold water. The filtrate and precipitate are next introduced into a known quantity of nearly boiling tenth normal potassium permanganate solution and stirred for 5 or 6 minutes until oxidation is complete. From 5 to 25 cc. of sulphuric acid are then added to the solution which is stirred and allowed to stand for some minutes, after which a measured excess of normal oxalic acid solution containing 50 cc. of concentrated sulphuric acid is introduced and the temperature kept at a little below the boiling point until the manganese hydroxide has completely separated. The liquid is then titrated back with permanganate solution, and the quantity of potassium calculated by multiplying the factor 1.09, by the oxygen value of the permanganate consumed by the original solution.

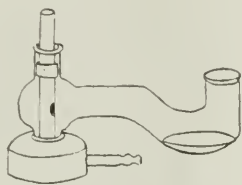
ANALYSIS OF RUBBER.

It is shown that rubber is not completely dissolved by solvents, such as benzene, petroleum spirit, and carbon tetrachloride, in the cold, the amount taken up varying with the state of division of the rubber, the temperature, the frequency of shaking, the duration of the action of the solvent, and the treatment to which the rubber has previously been subjected. Thus rubber is rendered more soluble by heating, and the solution is less viscous. By heating the rubber with the solvent more is dissolved, but solution is still incomplete. Hence the authors conclude that the results obtained by the methods in which the rubber is precipitated from its solutions by the addition of alcohol cannot be regarded as invariably trustworthy. Toluene will effect complete solution of rubber, but the reprecipitation with alcohol is unsatisfactory. The authors were also unable to obtain good results by the nitrosite method or by Budde's original tetrabromide method (*Gumme-Zeit.* 1907, 21, 1250); but the following modification of the latter method in which toluene is substituted for carbon tetrachloride, proved very satisfactory: One gram of the finely-divided sample is heated on the water-bath, with 60 cc. of toluene, the flask being vigorously shaken at intervals until solution is complete. The liquid is then cooled, made up to 100 cc. with toluene, and filtered through cotton-wool, 10 cc. of the filtrate evaporated, and the residue dissolved in 50 cc. of carbon tetrachloride. This solution is treated with 50 cc. of bromine solution (6 cc. of bromine and 1 gram of iodine in 1,000 cc. of carbon tetrachloride), and set aside for twenty-four hours, after which 50 cc. of absolute alcohol are added, the mixture thoroughly shaken, and the precipitated caoutchouc tetrabromide collected, washed first with a mixture of carbon tetrachloride and alcohol (2:1) and then with absolute alcohol, dried at 50° to 60° C., and weighed. The weight of tetrabromide multiplied by the factor 0.298 gives the amount of caoutchouc precipitated.—G. Fendler and O. Kuhn, *Gumme-Zeit.*, xxii., 132, 160, 215 and 249; (*Abst.*) *Analyst*, xxxiii., 60.

THE DETECTION OF PRESERVATIVES IN FOOD.

C. Mannich and H. Priess. (*Chem. Zeit.*, 1908, 32, 314-315) give the following method of applying the flame test which they claim enables 0.1 mgrm. of boric acid to be detected with certainty: A Beckman's "chemical distributor"

is fitted over the tube of a small Bunsen burner, as shown in figure. When a trace of boric acid is introduced into the distributor, and 5 to 6 cc. of methyl alcohol subsequently added, the vapors are drawn into the burner, and give a green-colored flame, which is visible for at least



Method of Applying Flame Test.

twenty seconds. The presence of copper or barium does not interfere with the test, but the sensitiveness of the reaction largely depends upon the ratio of 2 cc. of sulphuric acid to 4 cc. of methyl alcohol being maintained. When ash containing boric acid is tested, the yellow sodium flame appears first, but gives place in a few seconds to the characteristic green flame. In examining e.g. meat preparations, 5 grams of the finely divided sample are triturated with 0.25 cc. of 20 per cent sulphuric acid, and extracted with small portions of 90 per cent alcohol, until the united extracts amount to 50 cc. The liquid is then filtered, the filtrate mixed with 0.5 cc. of 15 per cent sodium hydroxide solution, evaporated to dryness, the residue ignited, and the ash tested as above described. As little as 0.005 per cent of boric acid may thus be detected.

C. H. La Wail and H. A. Bradshaw (*Amer. Journ. Pharm.*, 1908, lxxx., 171-172) recommend the following method for detecting benzoic acid in ketchup:

A mixture of 20 grams of the ketchup, 2 grams of sodium chloride, 5 cc. of concentrated hydrochloric acid, and 25 cc. of a saturated solution of common salt, is thoroughly shaken for five minutes and filtered, and the residue washed with a saturated solution of salt until 100 cc. of filtrate are obtained. The benzoic acid is extracted from this solution by shaking with quantities of 25 cc., 15 cc., and 10 cc. of chloroform, which is then allowed to evaporate at room temperature, the residue dried over sulphuric acid, and weighed. If the residue be impure, it should be dissolved in 10 cc. of a weak solution of ammonia, and the filtered liquid acidulated and re-extracted with chloroform. The benzoic acid may be titrated in alcoholic solution with $N/10$ potassium hydroxide and phenolphthalein as the indicator, and calculated to sodium benzoate, in which form it is usually added. Saccharin, salicylic and cinnamic acids are extracted by the above process. The last mentioned may be detected by means of a solution of manganous sulphate, which gives a precipitate with cinnamic acid, but not with benzoic acid.

NEW TEST FOR MINERAL OIL.

F. Schulz-Kolin (*Chem. Zeit.*, xxxii., 245) describes a new test for mineral oil in animal and vegetable oils. He finds that a solution of commercial picric acid in benzine

gives a red coloration with mineral oils. The reaction depends on some impurity in the crude picric acid (probably lower nitration products or higher homologues), since the pure acid gives no coloration. Rosin oil shows the same coloration as mineral oils, and the test may be regarded as a general one for the detection of the hydroaromatic hydrocarbons and their oxidized derivatives. Since the pure animal and vegetable fatty oils show no change in color with picric acid, this is a very convenient reagent for the detection of their adulteration. The presence of 1 per cent of vaseline in a dark yellow colored rape oil showed a distinct reddening on testing with picric acid; the test may also be used with linseed varnishes.

SEPARATION AND ESTIMATION OF COBALT AND NICKEL.

The double molybdate of nickel and ammonium, the formation of which affords a means of detecting nickel in the presence of cobalt (*Analyst*, 1908, 33), is completely insoluble in a saturated solution of ammonium molybdate, whereas the corresponding double salt of cobalt and ammonium is soluble. On this fact is based the following rapid method of estimating cobalt and nickel in the presence of each other: The solution containing the two metals is divided into two parts, in one of which the cobalt and nickel are estimated together by one of the known electrolytic methods. The other portion is concentrated, nearly neutralized (though still left slightly acid), treated with a very large excess of a saturated solution of ammonium molybdate, and with about 10 grams of ammonium chloride, and heated to about 60° to 70° C. with continual stirring. The liquid is then cooled, and the precipitated nickel filtered off, washed with a cold saturated solution of ammonium chloride containing some ammonium molybdate, and dissolved in hot water. From this solution the nickel is precipitated by means of potassium hydroxide and bromine, the nickel oxide washed and dissolved in an acid, and the nickel estimated electrolytically. The difference between the result and that obtained in the previous electrolytic estimation gives the amount of cobalt.—E. Pozzi-Escot, *Bull. Soc. Chim.*, 1908, (4) III., 776.

RAPID ESTIMATION OF NICKEL IN PRESENCE OF COBALT, IRON, ZINC, MANGANESE, ALUMINUM, CHROMIUM, URANIUM, MAGNESIUM, AND THE ALKALINE-EARTH METALS.

To the slightly acid and highly concentrated solution of nickel and other metals there are added a large excess of hot saturated solution of ammonium molybdate and a small quantity of ammonium chloride. The solution is kept at 60° to 70° C. for one or two minutes and well stirred, and then cooled to the ordinary temperature. The precipitate, which contains the whole of the nickel, practically all the iron and aluminum, a large part of the chromium and alkaline-earth metals, and a little manganese, uranium, and zinc, is filtered off, washed with a cold saturated solution of ammonium chloride, and treated with boiling water and ammonia, when only the nickel dissolves. The solution is filtered off, and the precipitate, if considerable, is dissolved in acid and reprecipitated with ammonia. From the filtrate, nickel is precipitated by boiling with sodium hydroxide and bromine, and finally determined electrolytically.

ally. The results are satisfactory.—E. Pozzi-Escot, *Ann. Chim. Anal.*, xiii., 215.

COLORIMETRIC ESTIMATION OF PHOSPHORUS IN STEEL.

G. Mission (*Chem. Zeit.*, 1908, 32, 633) claims that results accurate to about 0.005 per cent of phosphorus are obtained in ten minutes by the following method: One gram of the steel is dissolved in 20 cc. of nitric acid (specific gravity 1.2) in a 100 cc. flask, provided with a mark at 80 cc. The solution is boiled, 10 cc. of a 0.8 per cent solution of potassium permanganate are added, and the solution is again boiled for a few seconds, 10 cc. of a hydrogen peroxide solution, prepared by gradually adding 40 grams of sodium peroxide to a well-cooled mixture of 100 cc. of nitric acid and 900 cc. of water, are then added, followed by 10 cc. of a solution of ammonium vanadate, containing 2.345 grams of the salt and 20 cc. of nitric acid per litre, and the liquid again boiled until the hydrogen peroxide is completely decomposed. The liquid is diluted to 60 or 65 cc., cooled, 10 cc. of a 10 per cent ammonium molybdate solution are added, and the solution is diluted to the 80 cc. mark. The color is then compared with that of a standard steel, preferably in Eggertz tubes. The color obtained is due to a compound of the probable formula:



The standards keep well for about fourteen days.

PHOSPHORUS IN PHOSPHOR-TIN.

Messrs. W. Gemmel and S. L. Archbutt describe in the *J. Soc. Chem. Ind.*, May 15th, 1908, the method which they used in determining phosphorus in a large number of samples of phosphor-tin with good results. Two to five grms. of the sample were placed in a 500 cc. Jena flask fitted with a tap funnel and delivery tube. The tap of the funnel was a "two way," allowing gas or liquid to be introduced as desired. The absorption apparatus consisted of three Drechsel bottles, the first two containing about $\frac{1}{4}$ inch of liquid bromine covered with bromine water of about one inch in depth, and the third bromine water only. The air was first completely removed by passing a current of carbon dioxide through the apparatus for about 5 minutes; 50 to 100 cc. of concentrated hydrochloric acid were then introduced, and the contents of the flask gently heated. The sample dissolved readily, and it was obvious from the appearance of the first Drechsel bottle that vigorous action was taking place between the evolved gases and the bromine. When the action had practically ceased, the contents of the flask were gently boiled to effect complete solution of the tin, and to expel any phosphorous hydrides in the liquid. A current of carbon dioxide was then passed through the flask for five minutes to drive forward any remaining traces of evolved gases into the Drechsel bottles. These were then disconnected, the contents rinsed into a large beaker, the bromine boiled off, and the solution concentrated. From this solution the phosphorus was precipitated in the usual manner with magnesia mixture.

The alloys used in these tests contained no arsenic, which would have been estimated along with the phosphorus, had it been present. Any appreciable quantity present in the sample should subsequently be estimated in

the magnesium pyrophosphate by solution in hydrochloric acid, reduction, and precipitation with sulphuretted hydrogen. Before the precipitation of the phosphorus by magnesia mixture no precipitate was ever obtained with ammonia or sulphuretted hydrogen, showing that no tin had been carried over. The contents of the evolution flask were always tested for phosphorus, and nothing more than the merest trace was ever found.

"HYPO" METHOD FOR COPPER.

Mr. John W. Root describes in the October *Western Chemist and Metallurgist* the "hypo" method which he uses for the determination of copper. The method is as follows:

Proceed as usual when making copper determination, where zinc or aluminum would ordinarily be used in precipitating the metallic copper; but instead of using either of these elements, at this point, put the copper sulphate solution into a No. 4 beaker, dilute about half full, put in glass stirring rod, cover and bring to a boil.

While coming to a boil, heat to boiling a solution of 7 to 10 grains of "hypo" in about 100 cc. of water.

Pour the solution of "hypo" into the copper sulphate solution, using care so as to avoid a too violent action and consequent boiling over. Boil hard till clear. This takes 15 to 30 minutes, the glass rod preventing bumping.

Filter through a No. 597 filter. The copper sulphide being more or less granular, the filtration is very rapid. Wash well with hot water. Place the filter in small porcelain cups, dry and ignite at a temperature just sufficient to burn off the free sulphur and consume the filter proper, gradually raising the heat till all carbon is burned off.

Dump contents of cups into No. 3 beaker, nearly fill cups with nitric acid, warm to dissolve any small particle of copper oxide possibly remaining in cup and pour onto the copper oxide in the beaker. Heat, evaporate nearly to dryness, and proceed as usual either by the cyanide or iodide method.

If the following precautions are observed, a very satisfactory assay will be resumed: Dilute well the copper sulphate solution. Add carefully the hot "hypo" solution to the hot copper sulphate solution. Boil hard till clear. Dry thoroughly before igniting, and ignite at as low a heat as possible so as not to fuse the native sulphur, but instead burn down to a clean dry residue of copper oxide.

The great advantage of the scheme is the complete precipitation of the copper.

VOLUMETRIC DETERMINATION OF VANADIUM AND URANIUM.

The method that we are now using is as follows: From one-half gram to two grams of the material for analysis is taken as a sample. The size of the sample will depend on the amount of uranium present. If there is more than 0.25 gram present it will be difficult to filter and wash the uranyl ammonium phosphate. The weighed sample is transferred to a quarter litre flask and treated with 20 cc. of dilute sulphuric acid (1:5) and evaporated to fumes of sulphur trioxide. If organic matter is present it may be removed by the use of nitric acid with the sulphuric acid. After cooling and diluting to 100 cc., 3 cc. of hydrogen fluoride are added to oxidize the uranium and the vana-

dium, which will invariably be somewhat reduced by the digesting with sulphuric acid. An excess of sodium carbonate is next added and the mixture boiled for a few minutes, partially cooled, filtered and washed. In most cases it will be necessary to redissolve the precipitated iron, etc., with dilute sulphuric acid and repeat the treatment with sodium carbonate, combining the filtrates and wash waters. Ammonium carbonate may be substituted for the sodium carbonate used above, but care must be used to see that in either case there is quite an excess of the carbonate. Care must be used also to keep the solution oxidized at this stage by the use of hydrogen dioxide. The combined filtrates and wash waters are made acid with sulphuric acid and ammonium phosphate added ($\frac{1}{2}$ to—gram). The solution is next boiled vigorously to expel the carbon dioxide and made alkaline with ammonia. The thorough removal of the carbon dioxide is essential, as the uranyl ammonium phosphate is soluble in ammonium carbonate. This difficulty is in part overcome by boiling the mixture after the addition of the ammonia until the solution has a slight acid reaction due to the presence of acid phosphates or by the addition of acetic acid to a faint acid reaction. The uranyl ammonium phosphate must not be filtered from an alkaline solution, as a part of the uranium will probably remain in the solution. With these precautions the uranyl ammonium phosphate may be filtered and washed. Washing with an ammonium sulphate solution (1:25) helps to prevent the carrying through of the precipitate in the colloidal form. In case the amount of uranium is very small it may be desirable to add a small amount of aluminum sulphate to aid in the filtration and prevent portions of the uranium from being carried through the paper.

The filtrate, which contains the vanadium, is treated with 10 cc. of strong sulphuric acid and two grams of sodium sulphite. The excess of sulphur dioxide is boiled off and the solution immediately titrated, hot, with permanganate solution. A twentieth normal permanganate is recommended rather than a stronger solution. The iron factor of the permanganate multiplied by 0.9159 gives the vanadium factor, or by 1.631 gives the V_2O_5 factor.

The uranyl ammonium phosphate is dissolved with dilute sulphuric acid, granulated zinc of known purity is added and the reduction continued for 45 minutes. The solution is decanted from the zinc with the permanganate solution. It is important that the permanganate solution be not stronger than 1/20 normal, as the atomic weight of uranium is so great that it gives a large factor for the permanganate. The iron factor of the permanganate multiplied by 2.133 gives the factor for uranium, or multiplied by 2.5167 gives the factor for U_3O_8 .—W. D. Engle, *Western Chemist and Metallurgist*, Nov., 1908.

SEPARATION OF LITHIUM FROM THE ALKALIES AND BARIUM.

Evaporate the aqueous solution of the mixed chlorides just to dryness and digest the residue, weighing two grams or less, with about 25 cc. of pyridine at a boiling temperature for a few minutes, breaking up any large pieces with the end of a stirring rod. Allow the insoluble part to settle, which takes but a few seconds, decant the clear liquid

through a small filter, and wash the residue twice with small amounts of hot pyridine. Dissolve the residue in a small amount of water, evaporate barely to dryness, and repeat the extraction with hot pyridine. Combine the pyridine filtrate containing the lithium chloride; distill off the pyridine and finally convert the lithium chloride into sulphate and weigh. Wash the filter with water into the beaker containing the residue of chlorides insoluble in pyridine, evaporate to dryness, and weigh as chlorides.—L. Kahlenberg and F. C. Krauskopf, *J. Am. Chem. Soc.*, July, 1908.

RAPID DETERMINATION OF PETROLEUM NAPHTHA IN TURPENTINE.

To determine the amount of petroleum naphtha in a suspected sample of turpentine, 10 cc. are carefully measured into a 50 cc. carbon tube, which is graduated into tenths of a cubic centimeter.

Thirty cubic centimeters of aniline are now added and the mixture violently shaken for five minutes and left to settle until the liquid has become perfectly clear, when, if there is any petroleum naphtha present in the turpentine, it will be thrown out of solution and float in a layer on top, and the percentage can be readily ascertained. I get excellent results from this method, but care must be exercised that the aniline does not contain any water.—Henry C. Frey, *J. Am. Chem. Soc.*, March, 1908.

PREPARATION OF A SOLUTION FOR MAKING STANDARD SOLUTIONS OF SODIUM HYDROXIDE.

Prepare an approximately 50 per cent solution of sodium hydroxide by dissolving 50 grams of ordinary C. P. caustic soda sticks in 50 cc. of distilled water and leave tightly stoppered over night. The major portion of the impurities is insoluble in such a concentrated solution. The next day the proper amount of the clear supernatant solution is weighed or measured out, as most convenient, and diluted to the mark with freshly boiled, distilled water. Theoretically 8 grams or 5.25 cc. are required per liter of $N/10$ solution but, owing to the impurities which have settled out, it is safer to use 8.5 grams or 5.75 cc. per liter and then standardize against $N/10$ acid.—H. W. Cowles, Jr., *J. Am. Chem. Soc.*, July, 1908.

NEW VOLUMETRIC METHOD FOR COPPER.

To 0.5 gram of the ore in a 6 oz. flask, add 6 to 10 cc. of strong nitric acid, and boil gently, best over a free flame, keeping the flask in constant motion and inclined at an angle of about 45° , until the larger part of the acid has been removed. If this does not completely decompose the ore, add 5 cc. of strong hydrochloric acid and continue the boiling until the volume of liquid is about 2 cc. Now add gradually and carefully, best after cooling somewhat, 6 cc. of strong sulphuric acid, and continue the boiling until sulphuric acid fumes are evolved copiously. Allow to cool, add 25 cc. of cold water, heat to boiling, and keep hot until the soluble sulphates have dissolved. Filter into a beaker, and wash the flask and filter thoroughly with cold water. Nearly neutralize the filtrate with ammonia and add 10 to 15 cc. of strong sulphur dioxide water. Heat just to boiling and add 5 to 10 cc. of a 10 per cent solution of ammonium thiocyanate, according to the amount

of copper present. Stir thoroughly, allow the precipitate to settle for 5 or 10 minutes, filter on paper, and wash with hot water until the ammonium thiocyanate is completely removed.

Place the filter with its contents in a glass-stoppered bottle of about 250 cc. capacity, and by means of a piece of moist filter paper transfer into the bottle also any precipitate adhering to the stirring rod and beaker. Add to the bottle about 5 cc. of chloroform, 20 cc. of water and 30 cc. of concentrated hydrochloric acid (the two latter liquids may be previously mixed). Now run in standard potassium iodate solution, inserting the stopper and shaking vigorously between additions. A violent color appears in the chloroform, at first increasing and then diminishing, until it disappears with great sharpness. The rapidity with which the iodate solution may be added can be judged from the color changes of the chloroform.—G. S. Jamieson, L. H. Levy and H. L. Wells, *J. Am. Chem. Soc.*, May, 1908.

QUICK METHOD FOR CALCULATING CALORIFIC POWER OF PETROLEUM OILS.

Professors H. C. Sherman and A. H. Kropff have recently finished an investigation, the results of which they published in the October issue of the *Journal of the American Chemical Society*, which seems to indicate that the calorific power of petroleum oils can be determined with considerable accuracy from the density of the oil. By an examination they find for example that a sample of gasoline having a density of 0.71 had a calorific power of 21,120 B. t. u., a sample of kerosene having a density of 0.783 had a calorific power of 20,018 B. t. u., while a sample of California crude petroleum having a density of 0.9044 had a calorific power of only 18,580 B. t. u. By plotting the average figures obtained from the examination of 64 oils, the authors conclude that the calorific power, in B. t. u., may be found from the density by using the following formula:

$$\text{B. t. u.} = 18,650 + 40 (\text{Bé} - 10).$$

If it be desired to estimate the calorific power in terms of calories per gram, or to base the estimate upon specific gravity, or both, it need only be remembered that calories per gram $\times 1.8 = \text{B. T. U. per pound}$, and that specific gravity $= \frac{140}{130 + \text{B}^\circ}$, according to the standard used in

obtaining the Baumé figures here given; or the following estimate may be used, which being obviously only an approximate indication, is perhaps less likely to be misleading than is a formula:

A specific gravity 0.7—0.75 indicates about 11,700—11,350 calories.

A specific gravity 0.75—0.8 indicates about 11,350—11,100 calories.

A specific gravity 0.8—0.85 indicates about 11,100—10,875 calories.

A specific gravity 0.85—0.9 indicates about 10,875—10,675 calories.

A specific gravity 0.9—0.95 indicates about 10,675—10,500 calories.

Of the 63 samples here examined which fall within these limits of specific gravity, only two fall outside of the indicated range of calorific power by as much as 100 calories, and only seven by as much as 50 calories.

A SEPARATION OF IRON FROM MANGANESE.

If to a solution of ferric chloride containing free hydrochloric acid, pyridine, in slight excess, be added, the iron is completely precipitated as hydroxide. Aluminum, chromium, and zinc, under such conditions, are not completely precipitated, while manganese, nickel, and cobalt remain in solution. This method can therefore be used to separate iron from the last three metals.

When pyridine is added to a neutral solution of a manganous salt no precipitate is obtained. On warming, the solution slowly oxidizes and the manganese begins to come down. The rate at which oxidation takes place, however, is about $\frac{1}{3}$ as fast as the rate at which a manganous solution oxidizes when treated with ammonium chloride and ammonium hydroxide under similar conditions. If the manganous solution is made acid with a little hydrochloric acid before addition of the pyridine to slight excess, the solution may then be heated for ten minutes without oxidation. Consequently, pyridine possesses considerable advantages over ammonium hydroxide in the separation under question, especially when a large amount of manganese is present. Practically, its only advantage is its cost. A very fair separation can be made with one precipitation.

On washing ferric hydroxide precipitated by pyridine, no iron at first appears in the filtrate. As the excess of pyridine is washed out of the precipitate, however, colloidal iron passes through the filter. On washing the precipitate with pyridine water (1:500) the iron is completely retained by the filter.—R. B. Moore and I. Miller, *J. Am. Chem. Soc.*, April, 1908.

BLAST FURNACE SLAG.

Taking the total production at all blast furnace works in the world at about 50,000,000 tons of blast furnace slag for the last year and assuming that one ton of ungranulated slag measures, when broken up, about 20 cubic feet, the slag produced in one year represents a mountain of nearly 1,000,000,000 cubic feet.

John Payne, an Englishman, was the first who succeeded in utilizing blast furnace slag for big solid blocks—up to three tons in weight—which were successfully used for river and canal embankments. His method was patented in 1728.

Fritz Lurmann, when at Osnabruck, was the first who recognized and also utilized the hydraulic properties of granulated basic blast furnace slag for making bricks by mixing granulated blast furnace slag with lime cream and pressing this mixture into molds. The lime thus combining with the free silica in the granulated slag served as a cement, and the bricks became hard on free exposure to the atmosphere within about six to eight weeks.

In the last fifteen years 25,000,000 tons of small sized coal has been reclaimed from the anthracite culm piles of the United States.

AN INSTRUMENT FOR MEASURING COLOR.

Standards of color are by no means so easily established and maintained as are those for distance, weight, strength and the like. The latter are tangible, and under similar conditions permanent. But color, once established by means of a sample, is subject to change by time and exposure. The mixing of certain proportions of specified color ingredients does not insure absolute similarity of result because of the uncontrollable variation of the elements which make up the mixture.

Scientists and experts have long sought for a simple means of measuring color and of keeping records of the same so that it could be easily reproduced at any time. At last this has been accomplished in the colorimeter, invented by Mr. Frederic C. Ives, an optical expert.

This instrument is almost universal in its scope, convenient in its use, and available for use in the arts and industries.

The colorimeter consists of a rectangular box, having at one end three juxtaposed, apertures covered with color



Fig. 1.

screens, respectively red, green and blue, and one clear aperture, all having adjustable shutters; in the middle, an optical mixing wheel and field lens with circular aperture and prismatic central division, and at the other end an eyepiece.

Fig. 1 is a perspective view of the instrument as in use. Fig. 2 is a vertical section of the interior, and Fig. 3 a horizontal section.

The colorimeter outfit should be permanently installed on a solid support at a north window, where there is a good exposure of sky for illuminating the background. An east or west window can be used with the background at the south side, provided that the sunlight coming in the window is suitably screened from the colorimeter and the observer's eyes. In any case, the whole outfit should be screened by curtains if there are other windows in the room.

The "standard" white background adopted is a sheet of dense opal glass, backed by a sheet of white paper. If the colorimeter is properly directed, the light from this ground (light from the sky, diffusely reflected), will fill both sides of the divided field of the colorimeter evenly when the optical mixing wheel is rapidly revolved by the electric motor.

Referring to Fig. 3, G, R, B, are the green, red and blue color screens; D, the clear aperture. A is the optical mixing wheel, consisting of twelve convex lenses arranged on a circular base, which is revolved by a small electric motor to which it is attached. F is the field lens, and C a wedge prism which divides the field by a sharp line in the middle. H is the eyepiece. J is a hinged front carrying objective lens K and prismatic lens L, and provided with a spring clamp to hold a standard absorption cell. Assuming that the colorimeter is directed towards the standard white background, when the eye is placed at H, the left half of the circular field at F will be illuminated by either green, red or blue light, according to the position of the lenses in the optical mixing wheel with respect to the axis of the colorimeter. Revolving the wheel slowly by hand, one color after another crosses the half field, in regular procession. Revolve the wheel rapidly by means of the motor, and the three colors are so perfectly mixed in the field by persistence of vision that the result is a single even color, the character of which is susceptible of unlimited variation by alterations of the three color apertures, controlled by shutters which are operated by swinging levers on the outside of the case, and the colors measured in percentages on the edges of scales suitably placed.

At the same time that the revolution of the optical mixing wheel fills the left half of the field with evenly mixed colors, it fills the right half with white light taken directly through the prismatic lens L and aperture D and bent into the axis by the wedge prism C. The aperture D also has an adjustable shutter, but without scale. Alterations of this aperture affect only the luminosity of the right field.

If, now, the G shutter is open, but the R and B shutters closed, the left field of the colorimeter will appear a brilliant green. By closing the G shutter and opening the R shutter it is made a brilliant red. By opening only the B shutter it is made a beautiful deep blue. If two shutters are open and one closed, the color may be lemon yellow (G and R), peacock blue (G and B, or red-purple (R and B). When the field is lemon yellow, slow closing of the G shutter will make it first golden yellow, then orange yellow, then orange, then scarlet, then red. Slow closing of the R shutter, instead of the G shutter, will give first greenish yellow, then yellow-green, and finally pure green. Various mixtures of R and B give various hues of purple, and various mixtures of G and B carry through the various hues of peacock blue. The introduction of a little of the third color is equivalent to diluting these hues with white.

When the G shutter is opened to its widest limit (100 on the fixed scale), the R and B shutters may be opened by trial and error to exactly the necessary extent to make the left field a white exactly matching the right field in hue.

The R and B scales may then be set so that the levers, without altering their position, just touch (on their inside edges) the 100 mark on the edges of the respective scales. The two halves of the field should then match both in hue and luminosity; but if the right field appears brighter or duller than the left, the shutter of the D aperture must be readjusted to make the most accurate match possible. *Upon the accuracy of these two adjustments depends the degree of accuracy with which it is possible to make measurements.* Errors in the matching of the two fields at the start are necessarily added to errors in matching up colors.

Having matched the two fields, one may for practice, place a piece of chromium green glass over the prismatic lens L and aperture D (Fig. 3), and adjust the shutters to make the left field match the first. The first observation

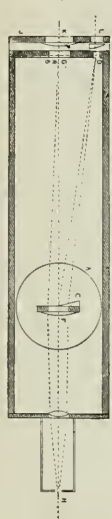


Fig. 3.

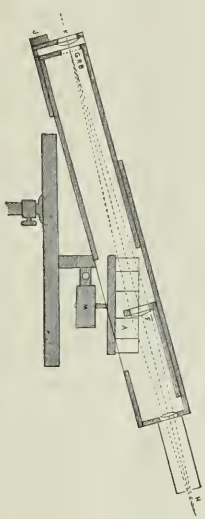


Fig. 2.

likely to be made is that the color of the right field appears very much duller than the color of the glass. It looks duller only because the luminosity is reduced. It has been proved that under these conditions the sensitiveness of the eye to minute differences of hue and luminosity is actually greater than when working with more light. If, now, the G shutter is opened wide, and the R and B shutters closed, the observer will certainly be astonished at the relative purity and brilliancy of the green in the left field, and will then understand why such a green glass would not serve for the green screen in the colorimeter.

There are several distinct shades of green glass manufactured, but the one sent out with the colorimeter for this experiment usually contains something like 36 parts of G, and 17 parts of R, and no B by colorimeter. It is easier to match this color than some others, because the absence of B eliminates one factor. There are only two apertures to adjust. The object being green, only the green shutter is

opened at first until the left field is nearly as bright as the right. It will then be seen that the glass is a yellower green than the colorimeter green, and the red shutter must be opened a little to match the hue. If the hues appear matched, but the luminosities do not, the G shutter must be opened or closed a trifle more, and the red changed to match the hue again, until both hue and luminosity match. Rest the eye a few seconds and look again. Use first one eye and then the other. If it looks right, read off the percentages on the scales and record them. Then try again and see how near the second measurement agrees with the first. After a little practice, the matching can be done quickly with not more than 2 per cent variations. The average of three or four measurements may then be taken as correct.

The amount of red which has to be mixed with the colorimeter green to match this glass may be seen by closing the green shutter after the match is made and measurement recorded, and will no doubt excite surprise.

The matching of pale tints is much more difficult than the matching of strong, colors like the green glass, because three colors must be co-ordinated both for hue and luminosity. Facility involves the knowledge, gained by experience, which of the three colors is most deficient or in excess in the left field, in order to promptly move the right lever and in the right direction, to make the required change of hue. If, when the hue is matched, the luminosities are not, the G shutter may be opened or closed a little in accordance with luminosity requirements, and then the R and B shutters re-set to match the hue again. This process can be repeated until both hue and luminosity match.

The perfect and quick co-ordination of so many factors admittedly involves some practice and training of the eye, and the first few hours' work may perhaps prove somewhat discouraging to anyone who starts out with the idea that it should be possible to measure colors with the same ease and precision as cloth or lumber, but remarkable ease and precision is acquired by practice. None of the factors involved in colorimeter measurements can be successfully eliminated; this particular co-ordination of factors must be accepted and mastered, because no other can possibly cover the ground and yield simple numerical formulae.

It is true that if the hue only had to be matched by manipulating the R, G and B levers, and then the luminosities matched by resetting the D shutter, the work would be much more quickly done by a novice; but it would then be necessary to have the D aperture scaled, and to do a sum in arithmetic to determine the real value of the readings in terms of matched white field luminosities. With a proper understanding of the correct procedure for regaining matches of hue with slight luminosity changes, the method adopted is much the better one.

When it is desired to measure the colors of opaque objects, such as colored or tinted papers, the sample to be measured is placed on a stand at the right side of an opal glass, and the colorimeter so directed that the image of the paper fills the right field, while the left field remains

illuminated by light from the opal glass. This adjustment is most readily made by substituting one of the ordinary lenses for the prismatic lens L. The colorimeter may be so directed that with the prismatic lens both fields are filled with light from the opal ground for convenience in setting for white field match, but the substitution of the other lens brings the object to be measured into the right field. Paper of some bright color may be used to make this adjustment, to avoid the risk or error, and then the paper to be measured substituted without disturbing the colorimeter.

The procedure is then exactly the same as in measuring the colored glass. The novice may experience some difficulty in obtaining precise and consistent measurements of only slightly different tints of nearly white paper, because of the number of factors that have to be precisely co-ordinated. A photometric device which has to match up luminosities only would be much easier to master, but would give no clue to hue differences, which is the most important function of a colorimeter. The first positively useful result obtained by a technical expert with an Ives colorimeter was the disclosure of significant facts with respect to samples of paper which it had previously been found impossible to discover by aid of tintometer outfit and chemical tests. The results were unexpected, but measurements made and repeated at different times by two observers were so definite and consistent as to leave no room for doubt.

One point to which particular attention must be called is the fact that in trying to make the left field white like the right, and also when measuring very light tints, the hue of the left field will appear slightly different at top and bottom. This unevenness, which might be deemed a defect, could be eliminated by a change of construction, but is not, because it adds to the sensitiveness of the instrument; thus, if the field matches better at the extreme top than at the bottom, or *vice versa*, then the most perfect match has not yet been obtained for the center; and the match which can be obtained by balancing this slight unevenness is more perfect than it might otherwise be made.

The color of quite minute transparent objects can be measured by putting them directly over the slit aperture D, which is only about 1 mm. wide, but opaque objects, in order to fill the right field by observation across the width of a window, must be at least 2x4 inches in size. Special arrangements can be provided to order for permitting convenient measurement of smaller opaque objects.

Printed forms are provided for recording the measurements and making various memoranda for reference. Thus, it is well to record not only the measurements of color, but also the quality of daylight illumination, whether blue, gray, cloudy or rainy sky, etc., and whether the observer's color equation is average normal, or as frequently happens, 2 to 5, or even sometimes 6 to 10 per cent, deficient in relative red sensitiveness. So far as at present known, such differences (within certain limits) do not materially affect the numerical values obtained for most colors so long as the start is made with matched

white field; but all such data may eventually prove useful, and in case of doubt it is desirable to be able to repeat measurements under the same conditions.

The G scale of the colorimeter is fixed, and provides the fixed factor with which everything else must be co-ordinated. The R scale is attached to a slider, and in one position will provide about 50 per cent more red light than in another when the scale reading is 100. There is a side scale to provide for the recording of the setting of the R scale, which will vary about 10 per cent (20 units on the side scale), with changes, in the quality of daylight from sea-fog or snowstorm to medium light blue sky. The colorimeter is so adjusted that for normal color vision, cloudy, rainy or snowstorm day, the back edge of the R scale (nearest the eye) will stand at about 10 on the side scale when the R lever, set for matched white field, touches the 100 mark. With blue sky illumination or a lower relative red sensitiveness of observer's eye, when white field is matched the R scale will have to be pushed forward until the edge of the lever touches the 100 mark again. After setting the R lever for white field, it should be held firmly in place by clamping to base with thumb and finger of right hand, while scale is slid into position by left hand.

The B scale is also a slider, but with less range of adjustment, and no side scale. A setting which is indicated by a line on the case will be found right for almost everybody, under all circumstances.

The optional mixing wheel motor should be run by current from a pair of Edison primary cells, and the speed carefully regulated by the small rheostat on the base board, near the motor, so that it is neither slow enough to cause a flickering nor fast enough to jar the colorimeter. Occasional readjustment of the resistance will be found necessary to maintain a fairly uniform speed. Dry cells, such as the "Columbia" or the "Ever Ready," can be used, but are erratic and short lived for this work.

All of the colorimeter lenses must be kept clean, not overlooking the field lens F and the wedge prism C, Fig. 4, which can be taken out by releasing spring catches, and put back, after cleaning, exactly as found. If the instrument is always covered up when not in use, the lenses should not ordinarily need cleaning more than once a month.

The first of these instruments was installed some months ago at the Arthur D. Little Laboratory, Boston, where its practical usefulness has been displayed in the everyday work of a large industrial laboratory. In fact, it was through Mr. Little's recognition of the value of such an instrument and his urgent appeal to Mr. Ives that the device was perfected.

Diatomaceous earth, infusorial earth, commonly called tripoli, is an amorphous form of silica from the silicious shells of small sea animals called diatoms. Diatomaceous is generally white and very fine grained. It is soft to the feel, but will scratch glass. It is not acted upon by acids and can be identified only by chemical tests. It is used in the manufacture of scouring soaps, etc., and is worth from \$20 to \$60 per ton at New York.

THE ELEMENTS OF CHEMICAL ENGINEERING.

III Conveying Materials.

(Written for The Chemical Engineer.)

(Continued from the November issue.)

LIQUIDS. (CONTINUED.)

Much more efficient injectors are made by compounding. Those of the Schutte and Koerting Co., Philadelphia, Pa., are among the most used of these in chemical factories. Coll's "Defiance Pump" has also been extensively used in tanneries and breweries. With this latter, it is possible to raise water 75 feet with a steam pressure of 60 lbs. The Schutte and Koerting Co. have given considerable attention to the building of injectors for use in raising chemical liquids, and manufacture them of lead, porcelain, stone-ware and hard rubbers. With certain forms of this injector it is possible to raise water as high as 100 feet. To do this a steam pressure of 100 pounds will be required, and the ratio of steam used to water elevated will be approximately 1 to 42. The increase in temperature of the water lifted, over the water in the supply tank will be about 32 degrees. With a steam pressure of 100 pounds it is possible to lift water 24 feet by suction, so that the injector may be located a considerable distance above the level of liquid in the supply tank.

These injectors are small and require less floor space than any other form of pump. For small capacities such as 1000 to 5000 gallons an hour, they are also cheaper in first cost than any other form of liquid elevator. Figure 1 shows "The Koerting Lead Siphon." This injector is especially applicable to the chemical industry, as it is made of lead, protected by an iron shell, and is provided with a platinum steam nozzle. These siphons are made for capacities ranging from 150 to 9600 gallons per hour and cost from \$20.00 for the smaller size to \$180.00 for the larger ones.

The table below shows the steam pressure necessary to raise acids of different density to various heights:

STRENGTH OF ACID IN DEGREES BAUME.		HEIGHT IN FEET TO BE FORCED.					
Pressure of steam in							
lbs.	...	10	20	30	40	50	60
20	24	22	20	18	16	14	
40	48	44	40	36	32	28	
60	72	66	60	54	48	32	
80	96	88	80	72	64	56	

Where lumps or solid particles are in the solution, the supply pipe to the siphon should be provided with a strainer.

For the operation of acid eggs and air lifts it is necessary to have at hand a supply of compressed air. In large plants, where several lifts are employed, steam driven air compressors located in the engine room will be found most convenient for furnishing this supply. In smaller plants a Westinghouse Air Compressor or a small belt-driven oscillating compressor, run from a line shaft will be found excellent for the purpose. Figure 2 shows the Westinghouse Air Compressor, which consists of a steam cylinder mounted directly over an air cylinder. The two

pistons (65 and 66) are on the same rod. The upper end of the latter is hollow as shown and in this hollow, the valve rod (71) to the steam chest works. When the steam piston (65) reaches the end of its down stroke the knob (k) on the end of the valve rod bears against the plate (70) which pulls the rod down and opens the valve admitting steam into the lower half of the steam cylinder (at b). At the same time the steam in the upper half of the cylinder is allowed to flow out at (c). When the piston reaches the end of the upward stroke the rod bears against the bottom of the hollow in the piston rod and the valves are reversed, steam entering at c and going out at b. These compressors may also be obtained belt-driven. These little compressors are cheap, costing only about \$80.00, are small and efficient. They may be fastened to an upright column or to the wall of the building, and take up no floor room.

The simple belt or pulley compressor shown in Fig. 3 may also be fastened to a column or post. Where these compressors are working at any considerable pressure, it

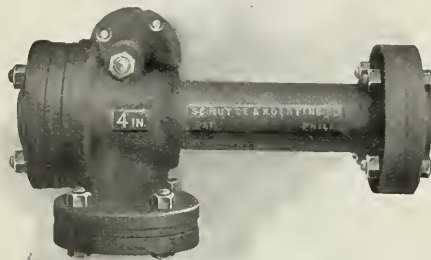


Fig. 1—Koerting Acid Lead Siphon. (Schutte & Koerting Co., Philadelphia, Pa.)

is necessary to water-jacket the air cylinder, in order to take care of the heat which is generated by the compression of the air.

With respect to the cost of appliances for moving liquids, the following figures will indicate the first cost of the apparatus.

Reliable simple injectors capable of elevating 650 gallons of water per hour cost from \$5 to \$8. Larger injectors with a capacity of 5000 gallons per hour cost from \$25 to \$30 and of 16,000 gallons, from \$90 to \$100.

Belt-driven rotary pumps have capacities and prices about as follows: 6,000 gallons per hour, \$75; 30,000 gallons, \$130; 60,000 gallons, \$200; 300,000 gallons, \$500.

Triplex stock pumps for moving thick liquids cost for a 4"x4" pump, \$180; 5"x8", \$337, and 8"x12", \$675.

Rotary pumps for soap and viscous liquids cost about \$50 for a small iron pump with a capacity of 3,000 gallons per hour and \$75 for one of 6,000 gallons per hour. Bronze pumps cost about twice as much as the iron ones.

Pulsometers capable of raising 1,200 gallons of water per hour, 25 ft. cost from \$70 to \$80. One capable of raising 6,000 gallons, \$150, and for 25,000 gallons, \$250 to \$300.

Stone-ware acid eggs cost from \$20 for one with a capacity of 25 gallons (per lift), to \$150 for one of 500 gallons. Automatic stone ware eggs, with a capacity of 25 to 40 gallons respectively, cost \$180 to \$190.

GASES.

Gases are moved by methods very similar to those em-

tary pumps, fans, gas compressors and blowing engines. For waste gases, fans and chimneys are usually employed.

Gas may be conveyed under almost the same conditions as liquids. Sheet iron pipes both corrugated and plain, cast iron and wrought iron pipes, and brick and concrete flues are all used. Flues made of sheet lead and protected

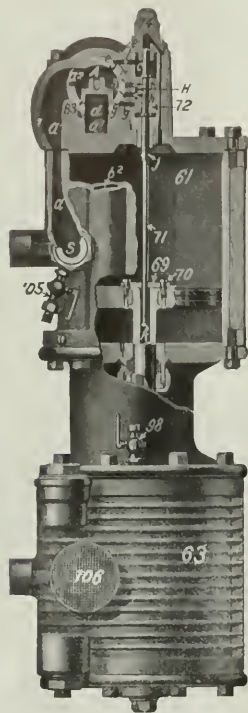


Fig. 2—Westinghouse Air Compressor. (Westinghouse Air Brake Co., Pittsburg, Pa.)

ployed for conveying liquids. They are carried from one part of the plant to another through pipes being made to flow therein by pressure, placed upon them by a pump or a gasometer or by the gas generator or retort itself.

The moving of gases may usually be considered under

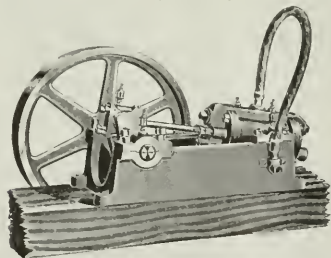


Fig. 3—Small Oscillating Air Compressor. (Norwalk Iron Works Co., Norwalk, Conn.)

two heads: First, the moving of gases which are to be used in some process or purpose, in other words valuable gases; and second, the carrying away of noxious or worthless gases. For moving useful gases there are used ro-

from outside injury by a wood casing are also used to carry gases which would corrode iron from one part of the plant to another. Where small amounts of gas are to be conveyed, lead, cast iron or wrought iron pipes may be used. Galvanized sheet iron pipes are used for air, where the pressure is small. Pipes of acid proof clay-ware are

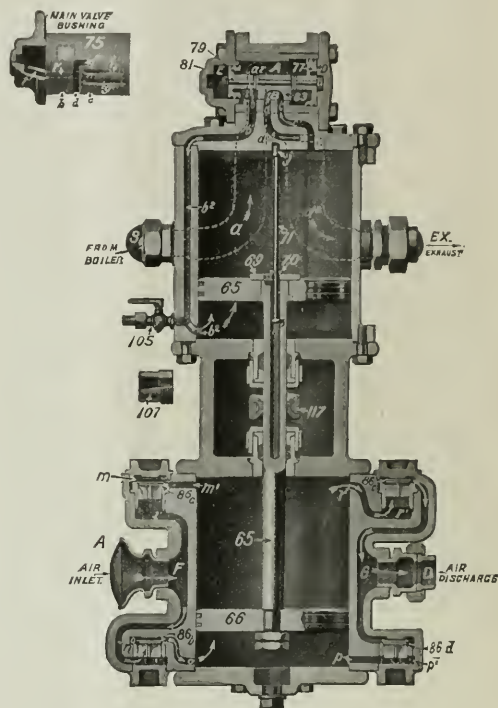


Fig. 4—Propeller Fan. (B. F. Sturtevant Co., Boston, Mass.)

also extensively used. Brick and concrete flues intended for acid gases are lined with acid proof tile or brick.

The flow of gases in pipes may be calculated from Molesworth's formulas

$$Q = 1,000 \sqrt{\frac{d^5 h}{sl}}$$

$$d = 0.063 \sqrt[5]{\frac{Q^2 sl}{h}}$$

$$h = \frac{Q^2 sl}{(1,000)d}$$

Where d = diameter of pipes in inches, h = pressure of gas in inches of water, s = density of the gas (air = 1), l = length of pipes in yards, and Q = quantity of gas in cubic feet per hour.

As an example of the use of these formulas, let us sup-

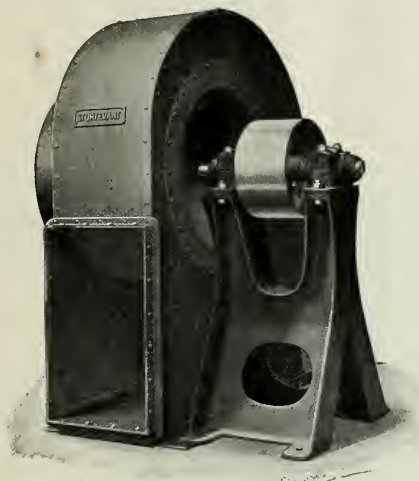


Fig. 5—Pressure Blower, Steel Plate Casing. (B. F. Sturtevant Co., Boston, Mass.)

pose we wish to find the quantity of oxygen which a sheet iron pipe 6 inches in diameter and 30 yards long will convey under a pressure of 0.578 ins. of water. The density of oxygen (air = 1) is 1.105. Substituting in the first formula we have

$$Q = 1,000 \sqrt{\frac{6^5 \cdot 0.578}{1.105 \times 30}}$$

The value of Q may be most conveniently found by the use of logarithms, whence

$$Q = 11,644$$

Therefore the pipe will convey 11,644 cubic feet of oxygen per hour.

Where the pressure is given in ounces per square inch this may be transferred to inches of water by multiplying by 1.73. To transfer from pounds per square inch to inches of water multiply by 27.68.

It is often necessary to know the pressure necessary to force a gas through a pipe. In this case the third formula is used. While to find the size pipe to convey a given volume the second formula is employed.

The fan may be described as a number of blades fixed about a shaft revolving at a high speed, the width of the blades making a slight angle with a plane perpendicular to the shaft. Fig. 4 shows a fan such as is used for ventilating work rooms. These fans may be operated from either

a line shaft or by a motor. They may be obtained in almost any size from a foot up to 10 or 15 feet in diameter. They are only suited to working against very slight pressure.

Pressure blowers (Figs. 5 and 6) differ from fans in that the width of the blade is parallel with the shaft and that the blades are enclosed in a casing of steel plate (Fig. 5) or cast iron (Fig. 6) or even brick work. The gases enter by an opening in the casing at the hub and are expelled by one at the periphery. The pressure at which the blower will deliver the gas will depend upon the speed at which it is run. The higher the speed the greater the pressure, and also the greater the efficiency. The following formula is given as showing the relation between the pressure and the velocity: $P = 0.0001706 V$, where V = the velocity of the tips of the blades in feet per second. Pressure blowers are best adapted for small pressures such as a few ounces. The greatest efficiency of a blower is usually obtained with a velocity of about 5,000 to 6,000 feet per minute peripheral velocity. With the best blowers the efficiency amounts to about 70 per cent.



Fig. 6—Pressure Blower, Cast Iron Casing. (B. F. Sturtevant Co., Boston, Mass.)

The horse power required to deliver air at a pressure of about one ounce amounts to approximately one horse power for the delivery of 2,000 cubic feet per minute. This applies to blowers having diameters of 5 feet and over.

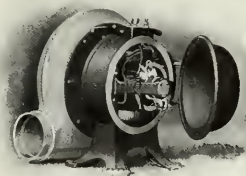


Fig. 7.

Small exhaust fans used for ventilation will move much more than this, even as much as 9,000 to 10,000 cubic feet

of air per minute per horse power, discharging it into the atmosphere.

The larger size pressure blowers may be run direct connected with a motor (Fig. 7), or engine.

These blowers may be used for moving corrosive gases, such as are given off from plating tanks and other chemical processes. In this case the corroding of the steel is prevented by coating all parts of the fan which come in contact with the gas with a coating of asphalt. Where the fan is to be placed in a room in which acid fumes are present, the outside of the fan also should be coated with asphalt. It is stated that even where this is not done these fans last quite a long time. They rust, of course, at first, but this rust seems to be a protection against further corrosion. It is unquestionably a better plan, however, to keep the blades and other exposed parts of the fan well coated with asphalt. In some instances copper and brass fans with

tions per minute. The small size fan costs \$164.50 and the large size \$457. Earthenware fans are expensive and easily broken and have comparatively low capacity. On the other hand it is possible to move with them many gases which it would be very hard to handle with a steel fan. The product delivered by stone-ware fans is also much purer.

An armored earthenware fan having an outer casing of cast iron is also made (Didier-March Co.) which is of course stronger than the simple earthenware fan.

Where it is desired to move gases under a greater pressure than a few ounces per square inch, high pressure blowers are used. One of the oldest of these is the Roots blower, manufactured by the P. H. & F. M. Roots Co., Connorsville, Ind. This blower is very similar in construction to the rotary pump shown in Figure 7 on page 137 of our October issue. This blower is made in a number of sizes and is capable of producing a pressure up to several pounds. The blades are coated with an especially prepared compound, which helps to make a tight joint between them. This blower requires about one horse power for every 150 to 200 cubic feet of air delivered at one pound pressure. They are slow speed machines, revolving at from 75 revolutions per minute for the large size up to 350 for the small size.

A newer form of high pressure blower, manufactured by the B. F. Sturtevant Co., Boston, Mass., is shown in Figure 9. This blower consists of an outer cast iron casing, a stationary core, moving idlers and impellers or blades. The idler and impellers move in opposite directions. The impellers fit into the idler as shown, the stationary core preventing leakage. These blowers have a capacity at $\frac{1}{2}$ pound pressure of from 5 to 15,000 cubic feet per minute.

Chimneys are extensively used in chemical plants for carrying off waste gases. Their first cost is high but on the other hand they usually deliver noxious gases at a point sufficiently high above the ground to render them harmless to surrounding vegetation, etc. If the gases themselves are hot, such as those from a furnace, the chimneys are, of course, the cheapest of all methods of carrying off waste gases, since they cost nothing to operate. On the other hand, if the gases are cold, or if their density when warm is greater than that of the air, the chimney, of course, will not carry them off and it is then necessary to create a draft in the chimney by means of a fire. Of course, most chimneys of this sort serve not only to carry off the gases generated from the plant, but also those from the boilers, the latter creating the draft. Where the fires have to be especially maintained to create a draft in the chimney, this is usually a more expensive method of getting rid of waste gases than is the use of fans and blowers. Even where the chimney itself is necessary in order to discharge the gases into the atmosphere at a point sufficiently high to render them harmless, it will usually be found that a fan may be used to advantage in connection with them.

Two forms of tall chimneys are now extensively used, namely those of concrete and of radial brick. The East-

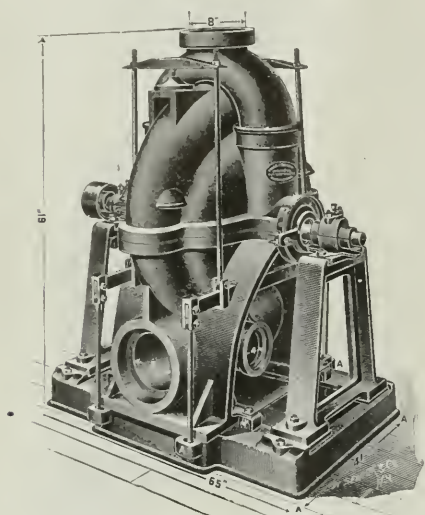


Fig. 8—Stoneware Exhaust Fan. (Chas. Graham Chemical Pottery Works, Brooklyn, N. Y.)

wood casings have been used. Fans having a lead lined casing and a lead covered or cast iron blast wheel are on the market and are used to draw the gases through the lead chambers of a sulphuric acid plant.

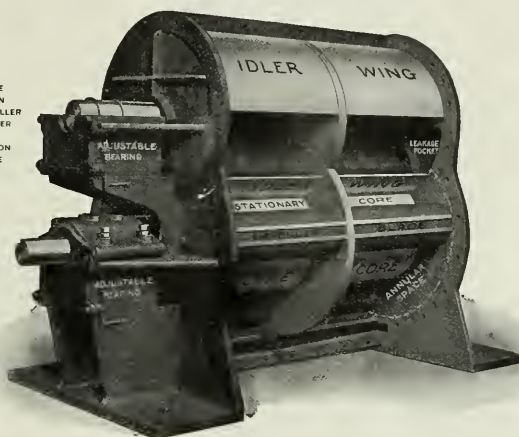
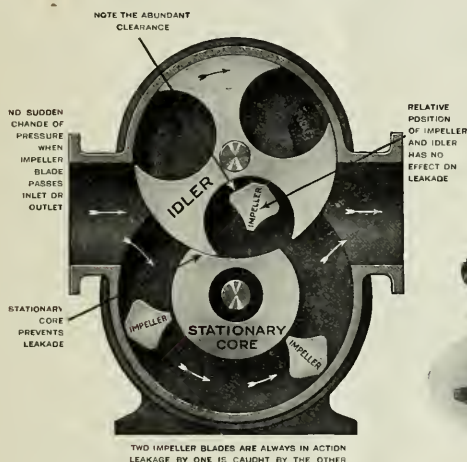
Exhaust blowers are also made of acid proof stone-ware. Figure 8 shows the form of stone-ware blower made by the Chas. Graham Chemical Pottery Works, Brooklyn, N. Y. The arrangement of the fan is such that acid fumes do not come in contact with anything but stone-ware itself. Even the iron shaft which actuates the fan is encased with stone-ware sleeves, so that the acid fumes do not come in contact with it. This serves to protect not only the fan but also the purity of the gas delivered by it. These fans are made in four sizes, designed to exhaust 50, 510, 1,000 and 2,600 cubic feet per minute respectively. The smaller size requires $\frac{3}{4}$ of a horse power to operate and revolves at 1,600 revolutions per minute. The largest size requires $2\frac{1}{2}$ horse power to operate and is actuated at 1,200 revolu-

man Kodak Co., at Rochester, N. Y., has a chimney 366 feet high made of radial brick. This was erected for them by the Alphons Costodis Chimney Constructing Company, Jersey City. This chimney is used to carry off nitric fumes from their collodion plant and prevent them from being a nuisance in the neighborhood of the works. It also carries off the gases from the boilers of the plant. This chimney is lined throughout from top to bottom with a special radial four inch acid resisting brick. A test of this brick showed that after being submerged in hydrochloric, sulphuric and nitric acids for several days it had not been damaged to the least extent. This lining was laid in acid-proof mortar which had been proved to success-

the draft will amount to 3¾ inches of water.

The first point to consider in designing a chimney for a chemical plant is the temperature of the waste gases to be carried off, their density or weight per cubic foot at this temperature, and their volume. The velocity of chimney gases in chemical factories is usually about 300 to 600 feet per minute. The area of the chimney can therefore be figured from this. In figuring the area of the chimney an allowance of two inches should be made for a lining of gas which does not move and which merely serves as a bearing upon which the other gases ascend. Where the chimney is also used for boilers, considerable attention must be paid to the design as the waste gases may cool the

Impeller and Idler Absolutely Independent of Each Other



The Sturtevant—the Only Single Impeller Blower Without Internal Contact

Fig. 9—Sturtevant Single Impeller Positive Pressure Blower. (B. F. Sturtevant Co., Boston, Mass.)

fully resist the influence of strong acid. This mortar consisted mostly of silicate of soda and asbestos wool.

Another chimney of the same type recently erected for the Boston and Montana Smelting Co., at Great Falls, Montana, is the largest in the world. This chimney also was made by the Alphons Costodis Co., of radial brick. It is lined with tile laid in acid-proof mortar similar to that of the Eastman Kodak Co., and is used to carry off the fumes from the smelter, which are detrimental to surrounding vegetation, owing to the presence in them of arsenic, sulphur dioxide, etc.

For a great many purposes large concrete chimneys could be used to advantage. These could also be lined with acid-proof tile.

The draft of a chimney is due to the temperature and density of the gas and height of the chimney. The draft is equal to the difference between the weight of a column of air outside of the chimney the height of the chimney and the weight of the column of the gases inside the chimney. In the case of the Great Falls chimney, it is anticipated that the gases will enter at 600 degrees Fahrenheit, and

chimney gases from the power plant sufficiently to destroy the draft and make poor combustion in the boiler fire boxes.

The intensity of a chimney draft expressed in inches of water may be found by the formula:

$$F = 0.192 h (D - d)$$

$$h = \frac{F}{0.192 (D - d)}$$

Where F = draft in inches of water, h = height of the chimney in feet, D = weight of the air outside the chimney and d = weight of the gases inside, in lbs. per cubic foot. Since a cubic foot of air at 32° F. weighs 0.0807 lbs., and the density varies with the temperature

$$D = \frac{0.0807 + 93}{T + 461} = \frac{39.8}{T + 461}$$

Where T = temperature of air (°F.). Similarly

$$d = \frac{493 w}{t + 461}$$

where t = temperature of gas (°F.) and w = weight

of a cubic foot of it. For Chimney gases from boilers and coal fires it may be taken as 0.0840.

The actual draft of a chimney is, however, only 75 to 80 per cent of the theoretical draft due to the losses from friction and the head necessary to produce the velocity of gases. The first of these losses is dependent entirely upon the area of the chimney, its height and the velocity with which the gases move through it. The friction loss is less with greater area and varies directly as the height and the square of the velocity. The head necessary to produce velocity varies directly with the square of the latter. The loss of draft due to friction and to produce velocity is, however usually inconsiderate compared with that due to friction in the flues connecting the furnaces, etc., to the chimney, the damper, passage of the air through the fuel, etc. For most purposes 0.5 inches of water draft are sufficient, where long connecting flues are used, however, a greater draft will be needed. The intensity of draft is independent of the area of a chimney. The quantity of gas, however, which can be carried off by a chimney depends upon its area of cross section as well as its height. For reasons of stability the cross section should never be less than one-fiftieth the height and usually much larger than this.

The area of a chimney may usually be calculated from the volume of gases to be carried away and the velocity it is desired that they shall have. The velocities usually met with are as follows:

In chimneys for carrying off noxious gases, 300—600 ft. per minute.

In boiler chimneys, 400—800 ft. per minute.

In cement kilns and metallurgical furnaces, 600—1300 ft. per minute.

For instance if it is desired to carry off 2800 cu. ft. of gas per minute from a chemical plant and the velocity of this is assumed to be 400 cu. ft. per minute, the area of the chimney should be $2800 \div 400 = 7$ sq. ft. or the chimney should have a diameter of 3 ft.

Kent gives the following rules for finding the area of chimneys for boilers:

$$E = \frac{0.3H}{\sqrt{h}}$$

$$A = \sqrt{E + 4}$$

$$d = 13.54 \sqrt{E + 4}$$

Where h = height in feet, H = horse power of the boilers, E = effective area of the chimney in sq. ft., A = side of a square chimney in inches and d = diameter of a round chimney in inches.

These formula may be used for any grate furnace such as those used for evaporating, etc., by substituting for H in them the value

$$H = \frac{Q}{5}$$

Where Q = quantity of coal burned upon the grate per hour. In furnaces of this class, this is seldom over 10 lbs. per square foot of grate surface per hour. If a furnace

under a still has a grate 4 ft. square its area will be 16 ft. or 160 lbs. of coal may be burned. Hence we may substitute 32 for H in the formula. If the height of the chimney to produce the desired draft was found to be 36 ft. the diameter would then be found as follows:

$$H = \frac{160}{5} = 32$$

$$E = \frac{0.3 \times 32}{\sqrt{36}} = 1.6$$

$$d = 13.54 \sqrt{1.6 + 4} = 21.6 \text{ ins.}$$

Connecting flues should always be introduced into the main flues at such an angle that the entering gases are traveling in the same direction in which the main flue will carry them and never at right angles to the current so as to cause "whirl pools" in the flue at this point. Cold gases may usually be conducted to the chimney best by a flue which dips slightly, while with hot gases, on the other hand, the flue should lead upward.

A NEW BURETTE CLAMP.

Figures 1 and 2 show a new form of burette clamp recently brought out by a prominent firm¹ of dealers in chemists' supplies. This clamp consists of the usual iron body and thumb-screw for fastening the clamp to the rod of the support. The clamp itself is of stamped steel fastened to a steel screw. The clamp is opened and closed by means of an iron cone-shaped nut moving freely over the steel screw. Fig. 1 shows the clamp open. By turning the cone-shaped nut so that it moves outward on the

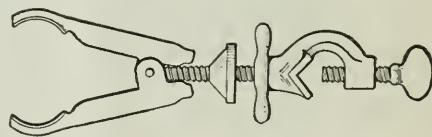


Fig. 1—Clamp Open.

screw, the cone engages the projecting ends of the clamp arms, forcing the latter apart and closing the jaws, as shown in Fig. 2. The clamp can be adjusted to hold a burette or condenser either upright, horizontal or at an angle by use of the check nut.

The advantages of the clamp are simplicity and the central position of the steel clamp, doing away with the



Fig. 2—Clamp Closed.

usual projection on the side of other forms of clamps, and also allowing the chemist to quickly lock and unlock the clamp. The clamp is also cheaper than the usual form, as it contains less parts.

¹Henry Heil Chemical Co., St. Louis, Mo.

THE CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

PUBLISHED MONTHLY BY

THE CHEMICAL ENGINEER PUBLISHING COMPANY

355 Dearborn Street, Chicago

Entered as Second Class Matter, Aug. 19, 1907, at the Post Office at Chicago, Illinois, March 3, 1879.

Subscription—United States, Cuba and Mexico \$2.00

Extra postage to Canada, 25c a year, to foreign countries 50c a year.

Remittances may be made by check, draft, or money order in favor of THE CHEMICAL ENGINEER PUBLISHING CO.

All matter connected with subscriptions or advertising should be sent to THE CHEMICAL ENGINEER PUBLISHING CO., 355 Dearborn street, Chicago. Anything intended for the Editorial Department should be sent directly to the Editor, Richard K. Meade, Nazareth, Pa.

NOTES AND COMMENTS.

THE FUTURE OF ANALYTICAL CHEMISTRY.

All right minded chemists who have had anything to do with general consulting work regret the tendency to commercialize analytical chemistry to the extent that the making of an analysis has become as unprofessional a matter as the making of a chair or a cupboard. Many manufacturers are beginning to ask for bids on their analytical work and are giving it, as the result of these, to the laboratory which will do it cheapest, without regard to the professional attainments of the man who is going to make the determinations. If this state of affairs continues, the profession of consulting analytical chemist will soon reach the point where our laboratories will be in charge of men with business heads, rather than technical ability.

The result of this tendency to commercialize analytical chemistry is beginning to make itself felt in a good many distressing ways. The following instance of this recently came to our attention. Two large foundries each employed a chemist. Both these men were graduates of well-known technical schools, with experience. A commercial laboratory was started in the neighborhood of these two foundries. This laboratory came to each of these plants with a proposition to make their determinations at a flat rate of 50 cents each; and finally, failing to obtain the work at this price, they lowered it to a figure which amounted to 23 cents for a silicon determination. At this quotation, both foundries were induced to let their chemists go. The commercial laboratory in question had for its head a young man of considerable business push, a college degree, and a year or two's experience in the laboratory of a large steel works. He knew that a Hungarian boy could be taught to make 20 or 30 determinations for silicon in a day, if somebody else did the weighing for him. He knew that a boy of slightly more intelligence could be taught to run as many volumetric sulphur determinations. Figuring the boy's wages at \$7 a week, he found it an easy proposition to make a fair profit on even silicons at 23 cents each. Whether the boy would run them correctly or not, is a fact which the average business man seldom considers. Under the education of some of our commercial laboratories, he is fast being taught that an analysis is an analysis, and that John Doe's work is as reliable as that of Richard Doe.

We have known business men who, when they were sick, employed the highest-priced physician in the town;

their chauffeurs were engaged at a monthly salary almost princely compared with that of the average chemist; when they had need to dodge the law, their attorney was a man whose fees always ran into three figures; yet these same men would sit down and write a letter to every laboratory, advertising in the engineering magazines, asking for quotations on analytical work, and invariably sent what they wished to have done to the man who made them the lowest price. This condition of affairs is increasing, rather than diminishing, and we think it is time for chemists to seriously take stock of their attainments and find out if they are going to make of analytical chemistry a craft or a profession.

It is not only the chemist of poor experience and doubtful professional integrity who is taking his services to the auction room. We know of several laboratories, headed by men of distinction and attainments in their profession, which are doing this. These men have probably been forced by circumstances, but nevertheless are cutting prices in a way which would rival a railroad rate war. We know of one large laboratory, headed by a man of the highest professional type, which formerly had its testing in the hands of experienced chemists and engineers, whose staff has now degenerated into a force of beaker washers and sample takers, few of whom would be able to pass the entrance requirements of a first-class high school.

This state of affairs will unquestionably be heightened, rather than diminished, by the adoption of standard schemes of analysis, standard specifications, etc. Nothing could be done to foster it faster than "standard methods." A boy can be taught these as readily as any other—in some cases even more readily so. The laboratory can always fall back, in case of an error, upon the defense that they used the standard scheme. No intelligence on the part of the analyst is necessary in selecting a method of analysis; all that he has to do is, parrot-like, to follow the operations laid down by standard rules. If standard schemes are widely adopted, we believe that the profession of an analytical chemist will degenerate to the point where it requires little more knowledge than that of compounding prescriptions or the following of any one of a half a hundred skilled crafts.

The chemical profession must sooner or later frown very hard upon unprofessional conduct, in the matter of charges, by a number of its members. If the manufacturer is to be encouraged to always give professional work to the lowest bidder, the profession will always be looked down upon. What would be thought of a doctor who would state beforehand his charges for curing a man of an ailment, or what would be thought of a man who would go from doctor's office to doctor's office, trying to find out which one of them would make him the lowest price for a consultation.

It is interesting to know in this connection that those chemists whose practice lies more strictly along the line of chemical engineering can work upon a much more professional basis. They are seldom asked to bid for a consultation, but are usually asked first for the advice and afterwards for the bill. This is the true professional method of handling the matter, and we believe that if

commercial laboratories would make a statement, when asked to bid upon analytical work, that their charges were dependent entirely upon the labor, professional skill, etc., necessary to make the analysis and that the work would be done first and the bill rendered afterward, the profession would be considered very much more seriously and their results be very very much more valued. Our own experience has been that men prize most what they pay the highest price for, and we think that the average man would consider as nearer right the silicon determination for which he had paid \$3, rather than the one which had been made for him at 23 cents.

MAKING BRASS.

It would be unwise for a brass founder who makes ordinary castings to use a highly refined spelter, as the cost is nearly double that of the ordinary grades, and no benefit would be derived from it. On the other hand, sensitive mixtures, such as cartridge brass or German silver, could not be made in a satisfactory manner were common grades of spelter to be employed. The sheet would not stand the necessary drawing and grading without cracking.

The common grades of spelter usually contain considerable iron and lead, but not enough to injure them for making brass castings or for use in galvanizing. In the manufacture of brass sheet, however, the iron hardens the metal so that a spelter low in iron and containing only a moderate quantity of lead is required. Lead does not injure the brass in many instances, and in such mixtures as screw rod, clock brass, or other free working mixtures it is added intentionally. As long as the iron content is not too high, brass can be used, although it may contain some lead.

In the manufacture of cartridge brass, german silver, spinning brass, and other fine grades of copper alloys to be rolled or drawn the "Bertha" or "Horsehead" brands of spelter are almost exclusively used. They are almost free from lead and iron. In the manufacture of spelter castings, too, or those made in metal molds for use in lamps, clocks and other ornamental work to be afterward plated, those brands are exclusively employed, as they have been found the only ones that successfully cast without cracking.—*Brass World*.

There is a simple and infallible test for the identification of the diamond. It is the hardest of all stones. Among the natural stones corundum ranks next, but carborundum (an artificial product) stands between corundum and the diamond. Therefore, obtain a crystal of carborundum or corundum. If the stone suspected to be a diamond will scratch either of them its identity as a diamond will be well established.

Spirits of camphor is said to be one of the best liquid erasers for removing Higgins' ink from tracing cloth. The only precautions necessary in using it are to place a piece of blotting paper under the tracing at place of erasure and not to rub too hard. Apply with a small sponge or a piece of clean cloth.

CHEMICAL SOCIETIES.

AMERICAN CHEMICAL SOCIETY.—W. R. Whitney, Pres.; Charles I. Parsons, Sec'y, Durham, N. H.

SOCIETY OF CHEMICAL INDUSTRY, NEW YORK SECTION.—George C. Stone, Pres.; H. Schweitzer, Sec'y, 128 Duane St., N. Y. City.
NEW ENGLAND SECTION.—Henry Howard, Pres.; Alan A. Claffin, Sec'y, Box 1189, Boston, Mass.

WESTERN ASSOCIATION OF TECHNICAL CHEMISTS AND METAL LURGISITS.—W. G. Swart, Pres.; H. C. Parmelee, Sec'y, P. O. Box 1121, Denver, Colo.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Charles B. Dudley, Pres.; Edgar Marburg, Sec'y, Univ. of Penn'a, Philadelphia, Pa.

AMERICAN ELECTROCHEMICAL SOCIETY.—E. G. Acheson, Pres.; J. W. Richards, Sec'y, Bethlehem, Pa.

AMERICAN LEATHER CHEMISTS' ASSOCIATION.—H. T. Wilson, Pres.; H. C. Reed, Sec'y, Stamford, Conn.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—Samuel P. Sadler, Pres.; John C. Olson, Sec'y, Polytechnic Institute, Brooklyn, N. Y.

FIRST ANNUAL MEETING OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.

The first annual meeting of the American Institute of Chemical Engineers was held at the Carnegie Technical Schools, in Pittsburgh, Pa., on Monday and Tuesday, December 28 and 29, 1908. The first session began Monday morning at 9:30 o'clock, and was opened by an address of welcome from Dr. Hamerschlag, director of the Carnegie Technical Schools. This was happily responded to by President Sadler for the institute. The secretary, Prof. J. C. Olsen, then read his report, showing the society to be in an unusually flourishing condition for so young an institution. Prof. Olsen's report was followed by the technical papers, of which four were read at this session.

The first paper by Edward Gudeman, Consulting Chemist, of Chicago, on "Technical Coal Analysis," outlined the methods which he considered most appropriate for this purpose. The next paper was by Mr. Wm. M. Booth, Chemical Engineer, of Syracuse, N. Y., on "Steam Power Plant Economies from the Standpoint of the Chemical Engineer." Mr. Booth's paper was an able exposition of the economies which can be effected in even some of our best power plants, mechanically considered, by the application of chemical principles to methods of firing, water purification, etc. Mr. J. C. Wm. Greth, Engineer of the Wm. B. Scaife & Sons Co., Pittsburgh, next read an interesting paper on "The Chemical Aspect of Impurities Which Cause Scale and Corrosion of Steam Boilers." His paper was devoted to an explanation of the scientific principles underlying the purification of water by chemical methods. The last paper of the morning was on "The Examination of Flue Gases in Boiler Tests" and was presented by Dr. H. August Humicke, Chemical Engineer, of St. Louis. Dr. Humicke's paper consisted of a critical review of the results of a large number of analyses of flue gases. Another paper on the program by Mr. A. Bement on "The Testing and Performance of Steam Generating Apparatus," was, owing to the absence of the author and lack of time, presented in a summary by the secretary, Prof. Olsen. All of the above papers will be presented either in full or abstracted in coming issues of THE CHEMICAL ENGINEER.

The hotel headquarters of the society were at the Hotel Schenley. Here the members had luncheon at noon.

At 2 p. m., the Institute visited the Duquesne Works of the Carnegie Steel Co., and were shown the laboratories and a large part of this interesting plant, under the guidance of Mr. J. M. Camp, Chief Chemist, and other officials of the company.

The evening session was devoted, in part, to the reports of the treasurer and the various committees. President Sadtler also delivered his address on "The Training of the Technical Chemist." His remarks were an able presentation of the subject and combined the viewpoint of both the teacher and the industrial chemist. At the conclusion of President Sadtler's address, Mr. Richard K. Meade, Chemical Engineer, of Nazareth, Pa., read a paper upon the "Heating of Industrial Furnaces with Pulverized Fuel." This paper was illustrated with some 25 or 30 lantern slides showing the appearance and construction of the various appliances used for drying, pulverizing and burning powdered coal.

Tuesday morning was devoted to another business session, after which Mr. Edwin T. Northrup, of Philadelphia, Pa., read a paper upon "Modern Electrical Resistance Pyrometry," in which he outlined the principles upon which this class of instruments for measuring temperature are constructed. His paper was a clear, concise exposition of the subject and the discussion showed the interest of the members in his remarks. Dr. F. W. Frerichs, president of the Herf & Frerichs Chemical Co., of St. Louis, next read a paper, illustrated by lantern slides, describing his methods and ingenious apparatus for testing liquefied ammonia gas, of which he is a large manufacturer.

In the afternoon several excursions were offered. The majority of the members attended the United States Government Explosives Testing Laboratory, where is on exhibition a large collection of apparatus for testing explosives, and also for testing the conditions under which mixtures of coal-dust, air and mine-gas are most readily exploded. There is also on exhibition here apparatus for mine rescue work. Another party visited the extensive plant of the Westinghouse Machine Co., and still a third party visited the Bessemer plant of the Edgar Thompson Steel Company.

At the evening session of the Institute, Mr. J. Herbert Brewster, Chemist of the State Board of Health of Indiana, gave an interesting talk, illustrated by lantern slides, on "The Sanitary Condition of the Southern End of Lake Michigan." This was followed by an able paper by Dr. Wm. M. Grosvenor, Chemical Engineer, New York City, on "Dryer Calculations and Dryer Design." Dr. Grosvenor's paper was a clear exposition, illustrated by various diagrams, showing the underlying principles upon which the drying of materials depend. The secretary, Mr. Olsen, in the absence of the author, then read a short paper by Mr. Thorn Smith, Consulting Chemist, of Detroit, Mich., upon "Some Experiments With the Ferric Iron Contact Method of Making Sulphuric Acid from Smelter Fumes." Another paper by Mr. J. A. De Cew on "Chemical Specifications for Sulphite Pulp," was also read by title at this

meeting. Mr. Grosvenor's paper and also those by Mr. Smith and Mr. De Cew will appear shortly in THE CHEMICAL ENGINEER. After resolutions had been offered, thanking the local committee, Mr. Camp, Mr. Greth, and Prof. James, for the pleasant way in which the institute had been entertained, the meeting adjourned.

At the meeting Monday, announcement was made that as the result of a letter ballot the old officers were re-elected, as follows: President, Samuel P. Sadtler, Philadelphia; vice presidents, Charles F. McKenna, New York; H. A. Hunnicke, St. Louis, and Edward G. Acheson, Niagara Falls, N. Y.; secretary, John C. Olsen, Brooklyn, N. Y.; treasurer, William M. Booth, Syracuse, N. Y.; auditor, Richard K. Meade, Nazareth, Pa.

One of the most enjoyable features of the meeting consisted in the exhibition of chemical engineering apparatus, held in the corridors of the basement of the Technical Schools. This exhibit will be described fully in our next issue, when more space will be available for the purpose. Among the firms who had representatives and apparatus present were the Schutte & Koerting Co., of Philadelphia; Didier-March Co., Hudson Terminal Building, New York City; Leeds & Northrup Co., Philadelphia, Pa.; Davis-Bournonville Co., Fuller Engineering Co., Allentown, Pa.; H. W. Dopp Co.; Cleveland Bronze & Brass Works, Cleveland, Ohio; Zarembo Co., Chicago, Ill.; Vulcan Iron Works, Wilkesbarre, Pa.; George M. Newhall Engineering Co., Philadelphia, Pa.

Those present at the meeting were: Wm. Booth, consulting chemist and engineer, Syracuse, N. Y.; Wm. Brady, Chicago, Ill.; J. H. Brewster, chief chemist, State Board of Health, Indianapolis, Ind.; J. M. Camp, chief chemist of the Duquesne plant of the Carnegie Steel Co.; P. W. Carlton, Cleveland, Ohio; C. W. Danforth, chief chemist of the Sharon Steel Co., Sharon, Pa.; D. J. Felkel, Pittsburg, Pa.; F. W. Frerichs, president of the Herf & Frerichs Chemical Co., St. Louis, Mo.; F. W. Frerichs, Jr., St. Louis, Mo.; J. C. W. Greth, manager of the Water Purifying Department of Wm. Scaife & Sons Co., Pittsburg, Pa.; Thomas Griswold, Jr., engineer, Dow Chemical Co., Midland, Mich.; Wm. Grosvenor, consulting chemist and factory engineer, New York City; Edward Gudeman, consulting chemist and chemical engineer, Chicago, Ill.; L. J. Hancock, St. Louis, Mo.; Edward Hart, president of the Baker & Adamson Chemical Co., Easton, Pa.; H. A. Hunnicke, chemical engineer, St. Louis, Mo.; J. H. James, professor of chemical engineering, Carnegie Technical Schools, Pittsburg, Pa.; Charles F. McKenna, consulting chemical engineer, New York City; Richard K. Meade, editor of THE CHEMICAL ENGINEER and consulting chemical engineer, Nazareth, Pa.; John C. Olsen, professor of analytical chemistry, Polytechnic Institute, Brooklyn, N. Y.; Henry S. Renaud of Waller & Renaud, New York City; R. F. Roeber, editor Electrochemical and Metallurgical Industry; Samuel P. Sadtler, of Samuel P. Sadtler & Son, consulting chemists, Philadelphia, Pa.; L. Veillon, vice president and manager Monsanto Chemical Works, St. Louis, Mo.; L. F. Vogt, Westinghouse Machine Co., Pittsburg, Pa.; Wm. Wilke, consulting chemical engineer, Buffalo, N. Y.

RECENT INVENTIONS.

The following patents relating to applied chemistry and metallurgy are reported for The Chemical Engineer by C. L. Parker, attorney in chemical patent causes, 908 G street, N. W., Washington, D. C.

902,581—Process of Extracting Tin. Emmerson C. Higgins, Bayonne, N. J. November 3, 1908.

The process consists in melting the tin by radiated heat without permitting the flame to contact with the scraps and throwing off the melted tin by centrifugal force.

902,607—Method For Producing Nitric Oxide. Isaiah L. Roberts, New York, N. Y. November 3, 1908.

The method consists in subjecting a mixture of nitrogen and oxygen to an electric arc containing chromium.

902,619—Process of Producing Plastic Explosives. Everard Steele, Penrhyneduraeth, England. November 3, 1908.

The process consists in forming a mixture of a pulverized inorganic oxidizing agent with a pulverized readily oxidizable organic substance insoluble in water but soluble in alcohol spraying said mixture with a solution of alcohol and castor oil to thereby dissolve the oxidizable substance, and then causing the alcohol to volatilize so that the oil together with the oxidizable substance forms a plastic waterproof coating upon the particles of oxidizing agent.

902,734—Smoke-Preventing Compound. Frank E. Jacobs, Washington, D. C. November 3, 1908.

The compound consists of a mixture of oxalic acid, a lye of carbonate of potash of commerce, chloride of sodium and ash.

902,755—Electrolyte for Electroplating. Otto Meyer, Richmond, Va. November 3, 1908.

The bath comprises a solution of chloride of a plurality of plating metals in alcohol.

903,138—Method of Purifying Water. William M. Jewell, Park Ridge, Ill. November 3, 1908.

The method consists in passing the water through a granular filter bed under the influence of a negative-head, the air separated from the water during its passage through the filter-bed being continuously discharged with the filtered water.

903,317—Process of Reducing Metallic Substances by Volatilization and Precipitation. George F. Rendall, New York, N. Y. November 10, 1908.

The process consists in reducing minerals by reducing the volatile particles of the ore in a closed chamber, concurrently therewith subjecting the ore and fume to a current of wood gas and subsequently precipitating the metallic contents of the fume.

903,357—Art of Manufacturing Salt. Pearl L. Clifton, Pomeroy, Ohio. November 10, 1908.

The process consists in, first, aerating salt brine; next, heating the salt brine while exposed to the atmosphere; next, subjecting the salt brine to a high degree of temperature in a closed evaporator by the application of steam in coils immersed in said salt brine, whereby a portion of the water therein is separated therefrom in the form of steam and released into a steam space within said closed evaporator above said brine; next, discharging the unevaporated brine into evaporators exposed to the atmosphere and, next, discharging the steam evaporated from the brine through steam coils immersed in the brine in said evaporators exposed to the atmosphere.

903,389—Process of Making Arsenate of Lead. Ellerslie E. Luther and William H. Volck, Watsonville, Cal. November 10, 1908.

The process consists in reacting with arsenic acid in solution, upon basic lead carbonate held in suspension, these reagents being present in the proportion of their combining weights.

903,471—Process of Producing Turpentine From Wood. William J. Hough, Toledo, Ohio. November 10, 1908.

The method consists in treating resinous wood with sodium sulfid to neutralize the resinous acids of the wood and dissolve the non-cellulose constituents thereof, and then volatilizing the terpenes with steam.

903,675—Paint. George D. Coleman, Brookline, Mass. November 10, 1908.

The paint consists of a binder comprising lead hydrate, varnish and raw linseed oil, mixed with granulated metal and pulverulent silica.

903,732—Copper Leaching Process. Frederick Laist, Butte, Mont. November 10, 1908.

The process consists in precipitating copper from a chloridized solution as the sub-chloride by first dissolving in the cold solution a quantity of sulphur dioxide, and then heating this solution, under pressure, to complete the reduction of the cupric chloride to cuprous chloride.

903,958—Smokeless Powder. Allen T. Cocking, Four Oaks, near Birmingham, England. November 17, 1908.

The explosive consists of a homogeneous plastic mixture of the following ingredients in approximately the proportion given: Nitroglycerin, 30 to 40 parts. Nitrocellulose, 60 to 50 parts. Vaseline, 2.5 parts. Olive oil, 2.5 parts. Potassium tartrate, 0.9 parts. Barium tartrate, 4.0 parts.

903,967—Sodium Perborate Containing Borax and Method of Producing Same. Ferdinand Fritsche, Rumburg, Austria-Hungary. November 17, 1908.

The process consists in treating peroxide of sodium with boric acid in the molecular proportions of 1.3 while the temperature is kept low, said reaction being carried out in presence of water and crystallizing out the borax-containing perborate.

904,054—Smelting Ores, Mattes and Metals for Armor-plate, Rails, etc. Willis E. Everett, Tacoma, Wash. November 17, 1908.

The method consists of smelting ores, mattes, alloys and metals by reducing the same in a furnace, by means of a flux that is composed of carbon and the cyanide of an alkali, and in casting the refined metal therefrom in suitable molds, thereby hardening and toughening it.

904,072—Process of Chemically Combining Gases. Dimmitt R. Lovjoy, Niagara Falls, N. Y. November 17, 1908.

The process consists in subjecting the gases to the action of electric arcs and removing the products formed from the region of the arcs by refrigerating the same to reduce said products to a non-gaseous state.

904,139—Process of Making Filaments for Lighting and Heating. George Michaud and Eugene Delasson, Paris, France. November 17, 1908.

The process consists in fusing the same in a powdered state in a fine stream, in an oxy-hydrogen flame and forming the fused material into a filament.

904,147—Manufacture of Sulphuric Acid. Hugo Peterson, Wimmersdorf, near Berlin, Germany. November 17, 1908.

The process consists in bringing gases in contact with cold nitrous vitriol of about fifty-five degrees Baume, immediately after the gases have left the last lead chamber and prior to the Gay-Lussac treatment.

904,250—Paint and Varnish Remover. Carleton Ellis, Larchmont, N. Y. November 17, 1908.

The composition comprises a volatile solvent and a solution of sulphur in a sulphur solvent capable of being chemically changed by exposure to produce an evaporation retarder for the volatile solvent.

904,263—Process of Obtaining Metals From Their Ores. Karl Kaiser, Berlin, Germany. November 17, 1908.

The process consists in heating the raw materials in an electric furnace, then forcing a gaseous oxidizing agent into contact with said heated materials, then forcing a gaseous reducing agent into contact with the heated material, leading off and condensing metals escaping in gaseous form, and running off the liquid metals into molds.

904,470—Manufacture of Artificial Para Rubber. John Blum, Boniface, Brussels, Belgium. November 17, 1908.

The Chemical Engineer

PUBLISHED BY

The Chemical Engineer Publishing Co., 355 Dearborn St., Chicago

Vol. IX.

FEBRUARY 1909.

No. 2

THE EXAMINATION OF FLUE GASES IN BOILER TESTS.*

H. AUGUST HUNICKE.

Chemical Engineer, St. Louis, Mo.

It seemed a matter of great interest to test the extent to which an examination of the flue gases will yield information as to the manner in which a firing process has been conducted. The very extensive work of the fuel-testing plant of the United States Geological Survey appeared to offer an unusual opportunity to investigate this subject.

After careful study of the data of the government report it soon became apparent that the variations of the firing process could not be followed by the individual analysis of the combustion gases made at intervals during each boiler test. This was disappointing because it was really the original purpose of the investigation. However, while a detailed study of each boiler test was not possible, some interesting features were revealed by a study of the averages of the flue gas analyses.

The chemical aspect of a combustion phenomenon is greatly obscured by the complexity of the fuel. While fuels of relatively simple composition such as coke, charcoal and anthracite among the solid fuels, and water gas among the gaseous fuels, offer no difficulty in the study of the combustion phenomenon from a chemical point of view, the soft coals, the ordinary bituminous coals or lignites, introduce factors which complicate matters very considerably, especially when combustion is not complete.

The fundamental principle upon which a study of the flue gases is based is the constancy of the ratio of the sum of the volume of oxygen and carbon dioxide and the volume of nitrogen. As the volume of the oxygen in the air is 20.93% of the whole, the sum of the volume of oxygen and carbon dioxide in a flue gas, omitting all interference for the time being, should be 20.93. The term "oxygen equivalent" will be used for the sum of volumes of oxygen, carbon dioxide and one-half of carbon monoxide calculated to its equivalent in oxygen as a means of comparison in this study of flue gases. Attention must also be directed to the fact that flue gas analyses do not represent the exact composition of the gases because all

of the hydrogen burnt to water is eliminated before the sample is measured for analysis. Sulphur dioxide, at least where only small quantities are involved, will be washed out of the gases before analysis is begun, larger quantities of the gas would in part be recorded as carbon dioxide, being absorbed by the caustic alkali used for the determination of carbon dioxide. Unfortunately the same must be said of carbon dioxide which, perhaps not to the same extent, may also be in part washed out of the gas in the process of collection, though much care is exercised to avoid this loss of carbon dioxide by all careful analyses. At best a flue gas analysis is only an approximation, and the difficulties of obtaining analytical results which represent the exact composition of the gases as they leave the flue make all calculations based upon them mere approximations. However, in spite of all the difficulties, it would seem interesting to investigate into the extent to which information as to the conduct of a firing process, can be derived from the results of the flue gas analyses.

The lower group of graphs in Fig. 1 represent the results of a series of calculations based upon the data of seventy-eight boiler tests. The heavy line was obtained from the experimental results by adding the percentage volumes of oxygen, carbon dioxide and one-half the carbon monoxide. The value of carbon dioxide recorded had to be multiplied by 1.0061 (44.26844) in order to correct for the differences of volume obtained by the use of the experimental value of the density of the carbon dioxide (44.268 when oxygen is taken as 32) and the density deduced from the atomic weight involved ($C = 12$, $O = 16$, $CO = 44$), the change from weight to volume making such correction necessary. The amount of carbon monoxide in nearly all tests was too small to make any similar correction necessary, and therefore its oxygen equivalent was obtained by dividing by two.

All calculations were based on the value of Morley and Raleigh.

The ratio of hydrogen to oxygen is given as 1 : 15.8792 = .00032 by Morley, or $O : H = 16 : 1.00761$. At 45 degrees latitude 100 c.c. oxygen weigh 1.42815 grams and 100 c.c. hydrogen weigh .08987 grams.

*Read at the Pittsburgh meeting of the American Institute of Chemical Engineers, Dec. 28, 1908.

Raleigh's values of densities for oxygen = 32 are:

Air	28.950
Nitrogen in air.....	28.1425
Nitrogen	28.060
Carbon monoxide	27.990
Carbon dioxide	44.268

Using Morley's value of weight of oxygen the following table was calculated:

	1 kg. at 0 and 760mm cubic meters.	cu. ft. in one pound.	1 cu. ft. weighs pounds.
Air	0.773538	12.391236	.080702
Oxygen	0.609815	11.210274	.080204
Nitrogen in air.....	0.705733	12.740775	.078451
Nitrogen	0.708072	12.784244	.078221
Carbon monoxide....	0.709811	12.812100	.078051
Carbon dioxide.....	0.505871	8.103502	.123403
Hydrogen	11.127184	178.245311	.005610
Water	1.243248	19.915478	.050212
Sulphur dioxide....	0.349577	5.590843	.178576
Methane	1.397436	22.385402	.044672

Conversion factors used: 1 pound = 0.453593.
1 cubic meter = 35.3156 cubic feet; 1 kilo = 2.20462.
1 cubic foot = 0.0283161 cubic meter.

Cubic meters in one kilo $\times 16.01891$ = cubic feet in one pound.

Inasmuch as the situation does not permit a direct attack of the problem, it became necessary to make certain assumptions defining limiting conditions as they may exist when all other factors are eliminated. A great number of assumptions may be made, the simplest, however, is that the hydrogen and carbon of the fuel are oxidized to water and carbon dioxide to the extent as indicated by the analysis. The latter records the amount of carbon dioxide resulting from the combustion while the water is eliminated by condensation thus not appearing in the gas analysis.

Let C = percentage weight of carbon in fuel.
H = percentage weight of hydrogen in fuel.
O = percentage weight of oxygen in fuel.
N = percentage weight of nitrogen in fuel.
S = percentage weight of sulphur in fuel.

Case I.—The oxygen required for complete combustion = $[8/3 C + (8H - O)]$, and therefore the total nitrogen resulting from the complete combustion of the fuel is equal to $[8/3 C + (8H - O)] \times 3.31 + N$.

The carbon dioxide resulting from complete combustion equals $11/3 C$.

For perfect combustion the maximum percentage volume of carbon dioxide in the flue gas is equal to $(11/3 C \times 8.10) \div 12.75 \times [8/3 C + (8H - O)] \times 3.31 + N + (8.10 \times 11/3 C)$.

A small correction must be made in this value in order to obtain the oxygen equivalent. This is done by using instead of the conversion factor 8.10 for carbon dioxide, $8.10 \times 1.0061 = 8.15$ and yields a value M.

The volume of carbon dioxide found by analysis is accompanied by a volume of oxygen equal to (1 minus

volume of carbon dioxide divided by M) multiplied by 20.93. The sum of these two volumes, to which is added one-half the volume of the carbon monoxide found by analysis, is the volume which would be occupied by the oxygen contained in the three gases, were it not in a state of combination.

Case II.—In practice neither is combustion complete nor are all combustible constituents of the fuel consumed. Few coals leave an ash free from carbon. Greater accuracy in the calculated value of oxygen equivalent might be expected by correcting for the loss of carbon in the ash. As more or less flue dust always accompanies the operation of combustion as ordinarily conducted, this may also be included in the correction. While it is not fully justified to assume that the flue dust contains the same amount of carbon as the ash, it was nevertheless decided to make the assumption because it was thought that however free from carbon the thoroughly burnt flue dust may be, losses of carbon are also due to soot which is carried off with the flue dust and is weighed as such. In the total averages of all tests this calculated value most closely approximates the results of analysis and was therefore used as a basis of comparison. No importance should, however, be attached to this preference.

Case III.—Many coals operated upon in the tests under consideration contained a not inconsiderable amount of sulphur and, while it is well known that this element may occur in a coal in various forms so that not all of it is burnt to sulphur dioxide in the process of combustion, it was nevertheless assumed that this was the case because it was desired to know the extent of maximum deviation of the oxygen equivalent resulting from the assumption which caused the most extreme deviation from experimental results. In all cases where the sulphur is only partially burnt or not at all because it is present in some form not subject to higher oxidation the oxygen equivalent will be found to be more nearly equal to that resulting when no account of sulphur is taken. It was assumed in the extreme case that all sulphur was eliminated from the gases by condensation with the water so that it formed no part of the volume of the sample of the flue gas analyzed.

These three values of oxygen equivalents thus obtained were plotted as shown in upper figure of figure 1. The space between the graphs is shaded and represents the range of variation of the oxygen equivalents for the various fuels where combustion is complete to the extent as the experimental results would indicate. The results of the flue gas analyses as recorded in the report do not include any determination of unburnt hydrocarbons which may and usually are to a greater or less degree present in flue gases resulting from the combustion of bituminous or gassy coals under the ordinary conditions.

A comparison of the values obtained by analysis and those resulting from the application of the method of calculation as described above shows that while a

number of the calculated values are very close to the experimental values there are a number of values which deviate, in some cases very considerably, being either short of the calculated value or in excess of the latter. All oxygen equivalents smaller than the calculated values would seem to indicate that either more or less unconsumed gas had reached the flues and appears in the analysis as "nitrogen" or else that the sample analyzed was taken mostly during the period of gasification when a greater preponderance of hydrogen would reduce the oxygen equivalent. The former case can presumably hardly be said to have prevailed to any great extent because the analyst would doubtless have determined the amount of unconsumed hydrocarbons remaining in the flue gas. It is therefore more probable that the discrepancy is due to the second cause. This discovery is rather disappointing

not be denied that there exists a parallelism which must be construed to mean that in the case of negative deviations combustion was incomplete, a deduction entirely in accord with the carbonic oxide determinations; while on the other hand the positive deviations would indicate that there has been an over-oxidation, a phenomenon not known in connection with the process under consideration. The question then arises, how to account for oxygen equivalents deviating from the experimental results which are greater than those obtained by calculation. We again have the choice of two interpretations, either the samples represented predominately the period of coke combustion, in other words that an insufficient number of samples were taken during the gasifying periods, or else that more particularly perhaps the hydrogen determinations in the fuel analyses, which latter forms

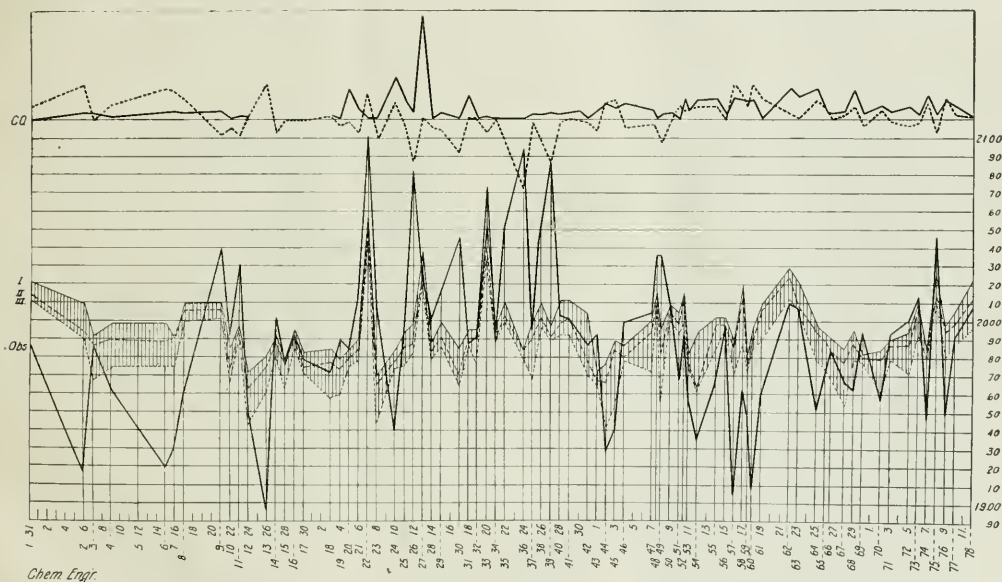


Fig. 1—Diagram Showing the Results of 78 Boiler Tests.

because, while such deviations were expected in the individual determinations and it was hoped that the progress of the combustion could be followed by just such deviations, yet no such results were looked for on the averages of entire tests extending over many hours. The number of flue gas analyses made during each boiler test were presumably too few and ill-chosen to permit the use of the results in the sense of representing true averages of the entire test.

In the upper part of the chart are plotted side by side the averages of the carbonic oxide as found by analysis and indicated by a heavy line and the deviations of the oxygen equivalents indicated by a dotted line. The latter values were so plotted that the negative deviations were plotted upwardly in the direction of the carbonic oxide values while the positive deviations are plotted negatively (downwardly). It can-

the basis of the calculations, is in error. The former interpretation is doubtless in most cases justified and merely corroborates the deductions already made from the negative deviations. Evidence which would seem to indicate that the hydrogen determinations of the ultimate analyses are not entirely trustworthy in all cases is not sufficient to draw any definite conclusions. The oxygen determination of fuels, being obtained by difference, is necessarily totally unreliable. Some effort should be made at an oxygen determination and there should be sought more complete knowledge of the discrepancies due to incorporating into the ultimate analysis the ash without corrections, which are necessary in consequence of the assumption that it forms as such part of the original one hundred per cent of the coal.

Perhaps it will be argued that it is hardly justifiable

to use the data given in the report of the survey in the manner indicated above, but it must be admitted that any set complete of data such as that referred to must bear the searching test of a balance sheet, not only of the B. T. U.'s but also the chemical masses which enter into the process. There seems certainly to be some unjustifiable elements of uncertainty due either to the analyses of the fuels or else those of the flue gases. It seems hardly justified to assume that the extreme variations of the oxygen equivalents should have to be accounted for entirely by the limited number of samples of the flue gases. When it is observed that the variation of the theoretical values of the coals under consideration at no time reach such extremes as do a number of the experimental values, all of which represent averages of extended periods of operation and not individual determinations, it becomes evident that even averages of the flue gas analyses of the various tests are in many cases open to serious criticism. Evidence can be cited that at least great care was exercised in drawing the gas samples for analysis. Whether the same may be said of the gas analyses is a matter of some doubt.

Without data of far greater completeness any attempt at using the analyses of the flue gases for extended researches into the study of the combustion process must fail. It is not necessary to add that the demand for greater accuracy applies to technical research such as that embodied in the report of the U. S. Geological Survey rather than to the commercial tests where greater accuracy than that necessary to secure practical information is of no purpose. Greater care should doubtless be exercised in the chemical work of such extended series of boiler tests as those of the survey because it is impossible to foresee what information may at any time afterward be drawn from the data. However technical may be the work in its grosser features, elements which are measured should be measured with precision. It is to be hoped that in the future more powerful methods will be brought to bear on the problem in order to ensure not only accuracy of a high order but also data which will most certainly yield information urgently needed as the competition between the different methods of fuel utilization become more keen.

The question of sampling has been too thoroughly discussed to require further reference at this occasion. Just a few words may, however, be permissible. The difficulty lies primarily in securing samples of gas which represent a definite period of the process, be it long or short. It has been the common practice to draw samples extending over long periods of time in order to secure samples of more average composition. Perhaps as the technique of gas analysis becomes more highly developed it will be found more satisfactory to make a great number of determinations on samples representing only short periods of time of known duration. Already the latter method is applied where carbonic acid recorders are used and

doubtless much of the value of these latter instruments is due to the greater frequency of the determinations.

In conclusion it must therefore be said that the data furnished by the report of the Geological Survey, which, it is assumed for want of something better, represent the present state of our knowledge on the subject, is not sufficiently reliable to draw from them information as to the management of a firing operation any further than the carbon dioxide, and perhaps also the carbon monoxide, determination warrants. We are still no farther advanced in our potency in this direction than we already utilize our powers to the fullest in our customary methods of conducting boiler tests. Carbon dioxide recorders are doubtless invaluable as important elements in the recording of the performance of boiler plants but we cannot for the present hope to gain information in greater detail than that most valuable instrument already records, unless technical research be directed to throw more light on the subject.

ON HIGH TENSION BRONZES.

BY SERGIUS KERN, M. E.

High tension bronzes—as, for instance, manganese bronze—deserve more attention than they usually receive from engineers. Apart from their physical qualities (tensile strength and elongation), which come near to those of steel castings, and the keeping of these qualities with small diminution at temperatures of high-pressure marine boilers (which the ordinary gun-metal fails to do), the high tension bronzes, containing about 60 per cent copper, 38 per cent zinc, and certain quantities of iron and manganese, have none or only small quantities of tin. This metal may be considered a speciality for liquation processes.

Such a nuisance as liquation we often observe in gun-metal castings for different fittings (valves, etc.) for high-pressure boilers. This is a great evil, as it gives rise to a heavy loss in ready machined fittings, which before delivery must stand serious and heavy hydraulic testing (very often 600 lbs. to the square inch). The cause of failures is chiefly due to liquation effects, which were not so harmful when small pressures in testing were applied (say, 90 lbs. per square inch), when marine boilers worked at low pressures. At those times gun-metal casting satisfied the demands of engineers.

Some years ago we made many trials and witnessed many experiments with Parsons' manganese bronze, and what struck us was the absence of liquation, speaking practically, in high tension bronzes, and that is the reason why we always insisted that such bronzes, apart from their physical qualities, must be more widely used instead of the old gun-metal.

In conclusion, we may add that small defects in high-tension bronzes when tried under hydraulic pressure, may be easily and safely chased by hammering. Such a method for gun-metal castings is out of the question.

THE USE OF PULVERIZED FUEL FOR HEATING INDUSTRIAL FURNACES.

By Richard K. Meade.*

Chemical Engineer, Nazareth, Pa.

In view of the fact that practically all the Portland cement at the present time manufactured in this country is burned with pulverized coal, and that this fuel is also used for the nodulizing of fine iron ores, it seems strange that this method of heating furnaces has not been more generally used in industrial and metallurgical work. The use of powdered fuel offers considerable advantage both in economy and ease of regulation over direct methods or the gas firing of metallurgical furnaces. It is possible to burn powdered fuel with almost the exact amount of air necessary for combustion. This means that a higher temperature can be obtained than is possible with producer gas or solid coal. It also means that the saving of fuel due to the smaller amount of excess air used is considerable. When powdered coal is used for burning, the ash is free from residual carbon, which means that all the carbon is burned, while with producers and furnaces in which the coal is burned or gasified from grates a portion of the carbon is always left unconsumed in the ash. Furthermore, practically all the carbon is burned to carbon dioxide, avoiding losses due to incomplete combustion to carbon monoxide.

Powdered coal has the advantage over gas firing in that the inherent losses of the gas producer are overcome. These losses are by no means small. It is estimated that the average loss of heat in the gasification of fuel, due to complete combustion to carbon dioxide, heat radiation, etc., is seldom less than 20%. If to this is added the loss due to the carbon which the ash carries away with it and the coal consumed in the boiler for the production of the steam required for the gas producer, it is safe to say that the loss may generally be considered as 30% of the thermal value of the coal.

The two objections which have been most raised to the use of powdered coal are the difficulty of its preparation and the danger of explosion. The latter has been very largely exaggerated. Powdered coal suspended in air is of course a very explosive substance. Indeed the energy of a pound of coal in this condition is greater than that of a pound of gunpowder. At the same time, however, powdered coal *en masse*, that is, when it is in a pile or in a bin, burns very slowly and with absolutely no explosive effects. In the earlier days of the use of pulverized coal in the cement industry, a number of explosions took place. Of recent years, however, these have been very infrequent, owing to the fact that the cement manufacturers have found the conditions under which explosions are most likely to occur and have guarded against them. The main principle in each case is to

avoid the coal dust being stirred up and mixed with the air.

The department of the plant in which the coal is ground should always be well ventilated so that no gas can accumulate. This can be accomplished by the use of a monitor running the full length of the roof and having slatted sides, so that any gases which may be generated from the coal will of course rise to the roof and so escape. Reinforced concrete offers a splendid material for the construction of fuel mill buildings, as the walls are straight and there are no projections to catch dust. In order that any fires started in the coal pulverizing department may not be communicated to other parts of the mill, this building should be fireproof and located with at least an alley between it and the other parts of the mill. Stairways, bins, platforms, conveyor-troughs, and elevator casings should all be made of metal. Platforms and steps may be best constructed of perforated sheet steel, as less dust collects on them in consequence. The electrical wiring of the lights, motors, etc., in these places should also be carefully done and no naked lights allowed in them. Most fires result from attempts being made to repair elevators and bins by the light of the ordinary workman's torch. The hammering shakes the dust from the sides, etc., of the elevator casing or bin and the naked flame ignites the dust laden air. Warnings against the use of torches, etc., in several languages with penalty of dismissal should be displayed prominently about the fuel grinding department and large signs, "*No Torches in Here*," should be placed upon the doors.

When fires occur in grinding mills, they may be best extinguished by the use of a tube of liquid sulphur dioxide (kept for the purpose) or they may be smothered by steam. All this is by way of precaution only, however, as fires now rarely occur in fuel mills. With a little care along the lines indicated, firing with coal dust may be considered just as safe as any other means of heating furnaces.

As to the process for preparing the coal for the burner, great strides have been made in pulverizer mills of all kinds in the last few years, and it may safely be said that coal can be pulverized at a cost far less than that necessary to convert it into a gas. A little further on in this article we will take up again more fully this question of cost.

Coal-dust heating is well suited to obtaining high temperatures in open hearths. It is possible with this method of firing to get as long a flame as can be obtained with any other. The system was tried on a reverberatory furnace at Murray, Utah, and here it was said that it was possible when allowed to do so for the flame to heat and slag the stack brick.

With a rotary cement kiln 60 ft. long it is possible by closing all dampers to obtain a flame almost the entire length of the kiln. It is also possible by finely pulverizing the coal and using a damper to concentrate the flame within the first 20 ft. This makes the

*Paper read at the first annual meeting of the American Institute of Chemical Engineers, Pittsburg, Pa., Dec. 28th, 1908.

coal-dust flame one which may be very easily regulated so as to heat most strongly just that part of the charge which it is desired to have hottest.

The objection which has been frequently raised to pulverized fuel is the settling of the ash upon the charge and also the clogging up of the regenerating ovens. In this connection, some experiments made by the writer several years ago are interesting. In a rotary cement kiln, six feet in diameter and sixty feet long, it was found that only half the coal ash fell on the charge and that the other half was carried into the chimney by the draft. The ash of pulverized coal is very light. The particles of course occupy practically the same volume as the coal particles and are only from 10 to 20 per cent the weight of the latter, consequently they are carried off by the strong draft which exists in most furnaces. At Murray, Utah, where pulverized coal was used to heat furnaces, it is said that the ash dust did at times settle on the charge, but never enough to cause appreciable insulating or blanketing of the latter.

Where regenerative furnaces are used to heat the air for combustion, this ash of course may collect in the checkerwork of these. Where pulverized fuel is used for burning, therefore, the regenerators should be designed with large ash settling chambers and wide passages in the checkerwork. Damour and Queneau in their treatise on industrial furnaces give as their opinion, that parallel counter-current regenerators are well adapted for use with furnaces heated by pulverized coal. These regenerators avoid the use of valves and it is possible with them to clean out the passages for the waste products by a jet of steam or compressed air or even with small and sharp water jets. Just enough water should be injected to have instantaneous vaporization. If this is to be done, care must be exercised to use in the regenerators, fire brick which will stand sudden cooling without "spalling." For such regenerators a design similar to a blast furnace hot stove would be advantageous, as these, being formed of a series of thin solid walls, are easy to clean.

As we have stated in the earlier part of this article, it is possible by means of powdered coal to obtain a much higher temperature than is possible with gas firing.

For example: The theoretical temperature of combustion of producer gas of this composition CO_2 , 5.8%; O, 1.3%; CO, 19.8%; H, 15.1%; CH_4 , 1.3%; N, 56.7%, burned with 25 per cent excess air, is only $1,376^\circ\text{C}$., while the theoretical temperature of combustion of coal of the composition H_2O , 1.9%; C, 74.9%; H, 4.8%; O, 8.6%; N, 1.4%, when burned with 25 per cent excess air, is $1,750^\circ\text{C}$.

It is possible with pulverized coal to use a much lower grade of fuel effectually than can be done with gas producers, for instance, at the plant at Murray, Utah, mentioned above, coal dust firing was adopted because the clinker of the coal used became very hard and massive, at first forming close to the grate-bars

and slagging together on the brick walls of the fire-box; they then gradually chilled and hardened from the bottom up. This, of course, necessitated a great deal of labor to break them up, get them out and put the fire on the grates again, the operation requiring from $1\frac{1}{2}$ to 2 hours, during which time the producer and furnace were practically idle.

It is also possible with powdered coal to obtain a much more regular heat than can be done by producer gas. In the latter case the gas is very irregular in composition unless the producers are very carefully handled, while with the former if improved methods for carrying the coal to the furnace are used it is possible to furnish the furnace not only with a fuel of uniform composition and in regular quantity, but also to so regulate the air as to burn this to the best advantage.

In coal dust firing, the best results are obtained in a chamber in contact with highly heated material such as fire-brick. If the flame on the other hand comes in contact with a cold surface, such as boiler tubes, the latter will reduce the temperature of the fuel and the air below the ignition point, resulting in incomplete combustion. For this reason heretofore coal dust firing of boilers has not been used successfully, but there is no reason why, if the proper types of furnaces are used in connection with certain types of boilers, this system of burning pulverized coal in connection with boilers, should not be successful. In the case of metallurgical furnaces, however, where the fire-brick and charge are both at a high temperature, combustion is complete and very rapid.

Coals rich in volatile matter such as gas coal and lignite are best suited to pulverized firing. The analyses given below are those of coals from various sections of the country, which have been successfully used for burning in a pulverized condition:

ANALYSES OF COALS USED FOR BURNING IN POWDERED FORM.

	Volatile			
	Moisture.	Combustible Matter.	Fixed Carbon.	Ash
Wellston, O.	2.04	41.96	42.82	12.27
Fairm't, W. Va.	1.38	35.04	56.03	6.27
Connellsville, Pa.	2.15	34.20	57.49	6.16
Illinois	7.50	30.70	53.80	8.00
Alabama	0.82	33.76	61.57	3.85
Hocking Valley.	6.59	34.97	48.85	8.00
Poor quality Pa.	2.10	29.63	51.28	16.09
Poor quality Pa.	2.32	27.08	47.34	23.26

It is possible, however, to burn coals very much lower in volatile matter than those given in any of the above analyses. In this latter case, it is only necessary to powder the coal very finely.

A saving which is effected by pulverized fuel over fuel burned on grates is the necessity of providing chimneys capable of producing sufficient draft to draw the air through the fuel bed. As is well known to engineers, the draft necessary for this purpose is considerable and uncertain, depending upon the nature of

the coal. With pulverized fuel all that is needed is sufficient draft to draw the products of combustion through the furnace with the desired velocity which can usually be accomplished by the use of a short stack.

The method of preparing the coal for burning consists first in crushing it roughly between rolls or in a small pot crusher, and then drying and powdering it so fine that from 90 to 95% of it will pass through a sieve having 100 meshes to a linear inch.

In order to get the greatest efficiency from the pulverizing machinery it is necessary to dry the coal until it contains less than 1% moisture. For this purpose three or four forms of apparatus are in successful use. Most of them consist of a rotary cylinder around which the products of combustion from a furnace pass. In some of them the gases after cooling somewhat, work their way back through the cylinder and form a vehicle for carrying off the moisture. These rotary dryers are inclined at an angle. The coal is fed in at one end and when fully dried falls out at the other. The cylinder is usually provided with shelves

through the cylinder by the flue without setting fire to the coal. The gases pass up through the cylinder to the stack. The coal is fed in at the upper end and falls out at the lower. These dryers cost about \$3,000 to install. Where hot blast stoves are employed it might be possible to draw off a portion of the air blown through these and, diluting it below the ignition point of coal, pass it through an ordinary cylinder dryer into which the coal is fed, and thus dry the latter.

Other forms of dryers used extensively for drying coal are those of the Ruggles-Coles Engineering Co., the F. D. Cummer & Son Co., and the C. O. Bartlett & Snow Co. The Ruggles-Coles dryer consists of an outer and an inner cylinder. The coal passes down between the two and the gases travel first through the inner and then back between the two. The Cummer dryer consists of an inner cylinder in a brick casing. A certain proportion of air and the gases of combustion are drawn from the brick chamber into the cylinder through hooded openings in the latter by means of a fan. The Bartlett & Snow dryer consists of a cylinder divided into four compartments by passages and encased in brickwork. The gases do not come in contact with the coal, but merely pass around the cylinder and through the passages in the latter.

Where the coal has been passed through a screen and consists of only pea and slack size crushing is unnecessary. After being crushed the coal may be ground in Fuller-Lehigh mills, Griffin mills, or tube mills.

There are a number of mills on the market which are advertised to crush and pulverize coal without drying. One of the best known of these machines is the *Aero Pulverizer*. It consists of three communicating chambers, each slightly larger in diameter than the preceding one, in which revolve paddles on arms whose length corresponds with the increased diameter of the chambers. A fourth chamber contains a fan which is used to draw the more finely pulverized material from one chamber to the next and finally to deliver it under the impetus of a forced blast to the burner. The air required for pulverizing purposes is admitted with the coal through inlets, in the feed device. The additional air required for purposes of combustion is admitted between the third work chamber and the fan chamber and may be so regulated as to produce either an oxidizing, a neutral or a reducing flame. No dryer is required, and the pulverized fuel is blown directly from the grinder into the furnace by the fans of the machine. From what we can learn of these machines from men who have used them, they do not grind very fine and require about 30-40 h. p. for every ton of coal pulverized. Unless a reserve machine is installed repairs to the machine necessitates shutting down of the furnace. For most metallurgical purposes where the gases leave the furnace at a high temperature there is no economy in grinding coal without drying and often there is a

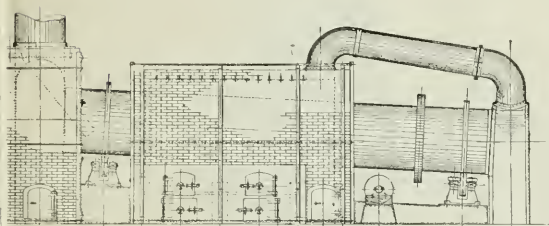


Fig. 1—Matcham Coal Dryer.

consisting of angle irons bolted to the sides and is often divided into compartments. The shelves serve to pick the material up and drop it through the hot gases passing through the cylinder. A good coal dryer will show an efficiency of over 50% and evaporate from 7 to 9 lbs. of water per pound of coal burned on the grate.

Fig. 1, shows the Matcham coal dryer (manufactured by the Fuller Engineering Co., Allentown, Pa.) used extensively in the Lehigh cement region of Pennsylvania, where more pulverized coal is burned than in any other single locality in the world, the amount approximating a million tons annually. This dryer, as the cut shows, consists of an inclined cylinder mounted on steel tires which run on rollers. The cylinder is revolved by means of a girth gear and pinion at an approximate speed of 3 to 4 turns a minute.

The cylinder is 30 ft. long and $4\frac{1}{2}$ ft. in diameter. It revolves partly in a brick housing which contains the furnaces. The hot gases pass up around the cylinder and this serves to cool them off to a temperature sufficiently low to admit of their being led back

positive objection to such practice. If the gases leave the furnace at a temperature of, say, 2,500° F., every pound of steam carries 2,600 B. T. U., while at 400° F., the average temperature of dryer waste gases, the steam carries off only 1,300 B. T. U., or about half as much. Where high temperatures are required, it will also be found much easier to obtain this degree of heat by the use of dry than wet coal. The water of course must be evaporated from the wet coal, and this alone utilizes a large number of heat units. The temperature produced in every case is that to which the heat produced by the burning of the coal will heat the products of combustion. For example, a coal containing only 0.3% water (as it does after passing the dryer) would give a temperature of 3,200° F. when burned with 25% excess air. The same containing 10% water would only give 3,000° F. when burned with 25% excess air. The use of dry coal is somewhat analogous to the use of the Gayley dry air blast.

As we have said before, after passing through the dryer the coal is crushed in a *pot crusher*. One of the best forms of pot crushers is what is known as a "coffee mill cracker." This works upon the same principle as a coffee mill and its action is a grinding one due to the toothed spindle rather than a crushing one, and hence it can not choke up with soft material, as a gyratory crusher would do from the packing of the material between the head and the crushing ring.

When a *set of rolls* is placed before the dryer, they are of the toothed form such as are used to crush run-of-mine coal. These rolls are usually about 24 in. in diameter with a 30-in. face. When rolls are placed after the dryer to prepare coal for a tube mill they should be plain-faced or only slightly corrugated. The toothed rolls usually reduce run-of-mine coal to 2-in. lumps and under and the plain face rolls will crush to lumps ranging from ½-in. down.

When coal is first passed through a screen and consists of only pea and slack size, rolls and pot crushers are unnecessary. After being reduced to 1-in. lumps and under the coal may be ground to the necessary fineness directly by either Fuller-Lehigh mills or Griffin mills or tube mills preceded by some form of preparatory mills, such as a Williams mill, a Steadman cage disintegrator or a set of smooth-faced rolls.

The *Fuller-Lehigh Mill* (Lehigh Car, Wheel & Axle Works, Catsauqua, Pa.) consists (see Fig. 2) of a horizontal ring or die *a*, against which revolve four balls, *b*. The balls are propelled by means of a pusher, *c*. The die, pusher and balls are made of chilled Swedish iron, and the latter weigh 260 lbs. each and are 12 ins. in diameter. They revolve at a speed of about 155 revolutions per minute and hence press against the die with enormous (centrifugal) force. The material to be ground is fed into the hopper, *d*, and from this into the mill; falls down into the pan of the mill, situated below the die, and is drawn up from this, in between the rapidly revolving balls and the stationary die, by means of air currents

induced by fans, *g*. The material is pulverized by the rolling of the balls against the die, the pressure of each ball against the latter being over 2,700 lbs., the grinding action being similar to that of a mortar and pestle. The fully pulverized material is sucked upwards by the fans, *g*, and blown through the screen by means of fans, *h*, falling down between this screen and the outer casing and being discharged from the mill at *n*. The coarse particles being too large and too heavy to be carried upward and through the screen by the fans, fall back into the trough to be again thrown up between the die and the balls, etc. The shaft, *i*, extends through the top of the mill and actuates the feeding device. The feed to the mill and consequently the fineness of the products may be controlled in two ways, either by a slide on the hopper, *d*, or by means of the stepped pulleys, *l*, connected to the screw conveyor by gearing, *m*. The mill is provided with two screens: one, the inner, *r*, of 1-in. mesh and made of very heavy wire to protect the

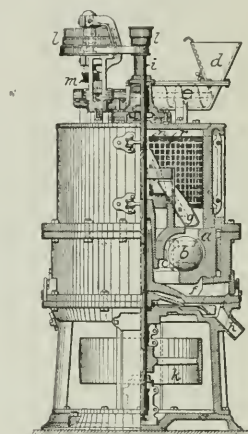


Fig. 2—Fuller-Lehigh Pulverizer.

outer one, *n*. The outer screen does not really screen, but merely controls the draft of air, and hence the fineness, since the greater the velocity the greater the carrying power of the air and hence the coarser the product. The mills grind to a fineness of 95%, passing a No. 100 sieve with a capacity of 6 to 8 tons per hour at an expenditure of 60 horse power. They cost \$3,000 and require but little to install, as the foundations are small. The mill is also made in a smaller size (33-in.) capable of producing 2½ to 3 tons of coal per hour.

The following shows about the capacity in pounds of coal ground to a fineness of 92%, passing a No. 100 sieve per H. P. hour by various pulverizers:

Fuller-Lehigh mill	150-250 lbs.
Griffin mill	100-160 lbs.
Tube mill*	60-125 lbs.
Aero Pulverizer	50- 65 lbs.

*Including set of rolls, etc., necessary to prepare material for it.

The method for burning the powdered coal is shown in Fig. 3. It consists of an injector, *a*, through which air is forced by a pressure blower, *b*, at a pressure of about 0.6 pounds. The coal is conveyed out of a bin, *c*, by a screw conveyor, *h*, falls into the injector, is sucked in and mingles with the air as it passes through the pipe, *f*, to the furnace, *g*. The injector is usually of cast iron, the pipe leading to the furnace is of galvanized iron and terminates in a nozzle of

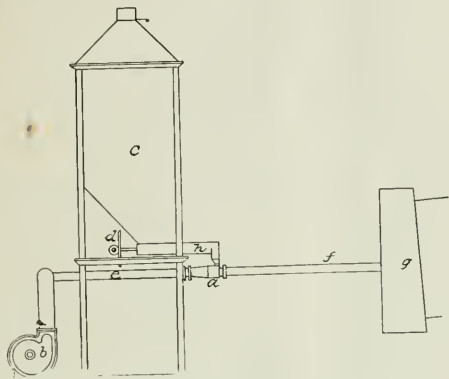


Fig. 3—Apparatus for Burning Powdered Coal.

wrought iron pipe, which projects for a foot or more through the hood into the furnace. The screw conveyor leading from the bin is run usually by a line shaft attached to the fan or the motor driving the fans. The connection with the shaft is made either by some form of speed controller, *d*, or else by a stepped pulley, so the coal feed can be regulated. The air blown in is usually constant and may be varied from only a fraction of that needed for combustion to the complete amount. In some cases air from the compressors or high pressure air is used, and in others a combination of the two is sought. The main object in any

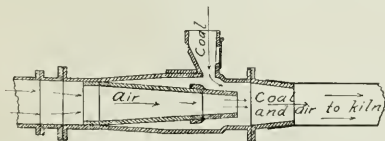


Fig. 4—Coal Burner for Injecting Coal and Air into Furnaces.

event is usually to carry the coal into the furnace and to get a good mixture of coal and air, the rest of the air being drawn in by the draft.

Fig. 4 shows the construction of an injector for use with low pressure air. The construction of the burner is evident from the drawing. Fig. 5 shows a compound burner intended for use with high pressure air. The coal drops down at the three points, *C*, *C* and *C*, the air from the compressor enters at *H. P. A.* and a certain amount of atmospheric air is sucked in at the openings, *A. A.* As to the relative merits of the two, the low pressure air is much the simpler of the two

where a compressor would have to be installed. With the low pressure system it has been found best to blow into the kiln at least 20% of the air necessary for combustion with the coal. With the high pressure air, however, only about 5% of the necessary air is obtained from the compressor. This air is usually delivered to the burner at about 80 lbs. pressure. Now to burn 100 tons of gas slack per day about 4,000 cu. ft. of low pressure air or 1,000 cu. ft. of high pressure air per minute will be needed. The theoretical horse-power required to supply 4,000 cu. ft. of air at $\frac{1}{2}$ lb. pressure amounts to 13.2 H. P. To compress 1,000 cu. ft. of air to 80 lbs. pressure, 137 H. P. will be required by theory. Hence there is considerable saving in the use of low pressure air.

Mr. Charles A. Matcham, the designer of the dryer previously referred to, has been granted a patent upon a system of burning which makes use of the natural draft of the furnace to suck the coal in. About 0.4 to 0.6 inches of water draft is needed for this system.

In installing a plant for pulverizing fuel, bins will be needed above the Fuller-Lehigh or the tube mill, but not above the dryer. The coal is carried on a belt or even in barrows or trams from the stock pile or the cars to the pot crusher. From this it may be carried up by a link-belt elevator into the spout leading into

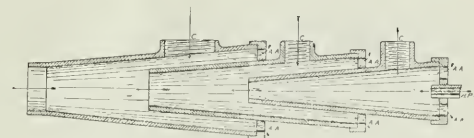


Fig. 5—Coal Burner for Use with High Pressure Air.

the dryer. From the dryer another bucket elevator takes it up into the bin above the Fuller-Lehigh mill and a screw conveyor takes the pulverized coal away from this. Another bucket elevator will be needed to take the coal up to the stock boxes above the burning apparatus. Screw conveyors may also be used to carry the coal either after it leaves the pot crusher or the dryer.

The cost of preparing the coal may be estimated as follows: One ton (2,240 lbs.) of coal will evaporate 15,000 to 16,000 lbs. of water. If the coal contains 6% moisture it will require one ton (2,240 lbs.) of coal to dry 116.6 tons of it. One attendant will be needed to look after dryer and pot crusher and to assist shoveling coal when necessary, and 1 attendant to shovel and keep dryer well fed. One 42-in. mill would have a capacity of about 120 tons per day of 22 hours, and would, with pot crusher, dryer and elevator, require about 90 H. P. Basing estimate on above figures, following results are obtained:

COST OF PREPARING 100 TONS OF PULVERIZED COAL.

Drying, Coal, $1\frac{1}{2}$ tons @ \$3.00.....	\$4.50
Attendance, 2 @ \$1.75.....	3.50
Attendance, 2 @ \$1.50.....	3.00—\$11.00

Grinding, Power, 90 H. P. @ \$4 per	
year, 350 days,	\$11.42
Attendance and supplies,	3.00
Repairs and interest on plant,	5.00—\$19.42
	\$30.42

Cost per ton, 30.42 cents.

COST OF PLANT FOR PREPARING 100 TONS PULVERIZED
FUEL PER DAY.

1 Pot crusher, set,	\$ 750
1 Matcham coal dryer, with stack erected,	3,000
3 Elevators,	750
1 42" Fuller-Lehigh mill, with foundations,	3,300
1 Idler,	100
1 Bin,	300
1 Motor, with wiring, etc.,	1,000
Shafting, belting, bearings, etc.,	1,000
Labor erecting,	800
Building and incidentals,	6,000
	\$17,000

Add to the above, \$4 per foot for 12-in. conveyor leading from fuel mill to furnace, and \$500 for each furnace for burning apparatus; storage bin and fans for air.

Cadmium continues to be produced in the United States by but one concern, viz., the Grasselli Chemical Company, of Cleveland, Ohio. The production in 1908 was about 10,000 lbs. At the beginning of the year the price was \$1.25 per lb. Later it was reduced to 75 cents. At the end it was 80 cents. These prices are for round lots. The production in Upper Silesia in the first half of 1908 was 35,000 lbs., against 30,500 in the corresponding period of 1907.

The Tennessee Copper Co., of Ducktown, Tenn., is manufacturing sulphuric acid from blast-furnace gases. Construction of the present plant was started early in 1906, and was completed late in 1907, the manufacture of the acid beginning about Dec. 1, 1907. The plant has been in practically continuous operation since that time. Its production is 200 tons of acid per day, and this will soon be increased to the full capacity of 400 tons per day. Their ore is a low grade copper ore containing as much as 30% sulphur.

To deposit copper upon glass, one part of freshly distilled phenylhydrazine is heated in two parts of water until the solution is clear. A warm solution of cupric hydroxide in ammonia is added, followed by a hot 10% solution of caustic potash until a slight precipitate of cuprous hydroxide occurs. If the solution, in this condition, is brought in contact with a clean glass surface, a bright, perfectly reflecting deposit of copper forms upon it. The copper thus deposited is washed in an hour with water, then with alcohol, and finally with ether, in order to dry it without rupture. It is then coated with lacquer or varnish.

WOLCOTT GIBBS.

In the death on December 9th of Dr. Wolcott Gibbs, the profession of chemistry in the United States has lost one of its most eminent men. It is true that he had retired from active duties as a college professor and teacher twenty-one years ago, so that the younger generation knew him only as a name, but the eminence achieved by him a generation ago, when he was a fruitful investigator and prolific writer, combined with the affectionate recollections of scores of his former pupils, kept his name in the list of America's great chemists down to the last.

Dr. Gibbs was born in 1822 and was a graduate of Columbia College and the College of Physicians and Surgeons of New York. His chemical education was obtained at the University of Berlin, under Liebig at Giessen and at the College of France in Paris. For fourteen years he was professor in what is now the College of the City of New York, and in 1863 went to Harvard as Rumford Professor and head of the chemical laboratory of the Lawrence Scientific School. It was during the 24 years of his active connection with this institution that his greatest activity was shown, although his joint work with Dr. F. A. Genth on the ammonia-cobalt bases, issued by the Smithsonian Institution, was published while he was at New York. Besides many new analytical methods worked out by himself or jointly with his students, he made most elaborate investigations on the complex acids of tungsten and molybdenum, discovering over fifty new series of compounds. In 1887 he became professor emeritus and retired to Newport, R. I., where he passed the remainder of his days. Dr. Gibbs was one of the original members of the National Academy of Sciences and for many years its president. He was an honorary member of both the English and the German chemical societies, as well as of many American scientific societies, and received the honorary degree of LL.D. from five American universities. A man of commanding figure and dignity, he will long be remembered as a great teacher and investigator.

S. P. SADTLER.

The amount of sulphur daily wasted by smelting works is something appalling. A single plant near Salt Lake City discharges 500 tons of sulphur, as SO₂, into the atmosphere every 24 hrs., while the Washoe, Garfield and other plants probably exceed this.

Artificial camphor is produced by heating turpentine with anhydrous oxalic acid. The pinyl oxalate and pinyl formate produced, when distilled with steam, yield respectively camphor and borneol. By oxidation the borneol is then converted into camphor. With the exception of the fact that it is optically inactive, artificial camphor so prepared agrees in all other essentials with ordinary camphor. It has yet to be shown, however, that its medical properties are the same.

THE CHEMICAL PLANT

SOME EXPERIMENTS WITH THE FERRIC OXIDE CONTACT METHOD OF MAKING SULPHURIC ACID FROM SMELTER FUMES.*

By THORN SMITH.

Superintendent of the Acid Department, Ducktown Sulphur, Copper and Iron Co.

The Ducktown Sulphur, Copper and Iron Company of Isabella, Tenn., has been for the past five years and more conducting experiments tending to eliminate the sulphur dioxide fumes resulting from the smelting of heavy copper sulphide ores. Early in the work it became evident that nothing short of the manufacture of sulphuric acid would solve the problem economically. Experiments were therefore conducted in that direction. The almost complete absence of arsenic and other platinum poisons caused us to believe that the platinum process was best adapted to existing conditions. Results obtained in experimental work, using the actual smelter fumes, were highly satisfactory. Later, owing to a possible future change in the ore constitution, it was decided that a combination of the iron and platinum processes offered better advantages.

At first, caution being advisable, a ten-ton plant using the oxide process alone was contracted for, leaving the platinum addition until such a time as the iron process had demonstrated its capacity. Assurance was given by the designer that at least a 50 per cent conversion could be maintained and this without a preliminary drying of the smelter gases.

The gases as they entered the acid system averaged about 1,000 degrees centigrade and by means of a so-called equalizer, constructed of fire brick, it was expected that a sufficiently high temperature could be maintained without additional heating of the gases before conversion. The equalizer was followed by a series of ordinary pyrites burners, slightly modified to meet the conditions imposed. The rest of the apparatus was probably not far different from the ordinary forms used in this process.

It is not the purpose of this article to criticize the design or construction of the plant hence I shall abstain as much as possible in this direction. However, it was immediately evident to me that with a 50 per cent conversion, coupled with the fact that the rainfall is the heaviest in the United States and consequently that the humidity is high, 100 per cent acid could not be made as promised by the designer. In fact, that unless the conversion was maintained at a point considerably in excess of 50 per cent our resulting acid would be very much weaker.

The operating plant was to deflect, by means of fans

at the end of the acid system, sufficient gas from the dust chamber of the smelting plant, to make the required ten tons of 100 per cent acid. The gas passed first through the equalizer, previously mentioned, then through the several burners containing burning sulphur ore. These burners were for the purpose of enriching the gas and at the same time serving as a filter for the greater part of the dust. It was assumed, myself to the contrary, that the zinc oxide, a constituent of the dust, was volatile and would not collect on the burner ore or on the iron oxide in the contact chamber. But a few days' operation were necessary to show that the zinc oxide did collect and coat every portion of the plant from end to end and particularly the contact-mass owing to its large area and the consequently slower movement of the gas.

It was early evident that the contact action was far below 50 per cent simply because the make of acid was extremely low in quantity. It was impossible to ascertain the conversion even approximately owing to the location of the fans at the end of the system which caused an inrush of extraneous air at every possible opening, let alone that due to the frequent opening of the burner doors for charging. The very low conversion, together with the fact that the gases carried their normal atmospheric moisture and also a considerable additional amount from the moist ore of the smelting furnace made an extremely weak acid, which as soon as condensed, attacked the iron parts of the plant causing excessive damage.

Efforts were continued to overcome the manifest difficulties. Opinions differed as to why the yield was so extremely low. I maintained that the zinc oxide coated the contact mass to such an extent that good action was defeated, others stuck to their contention the zinc oxide was volatile, and this in the face of the fact that all the doors and the spent oxide shaken from the contact chamber, were densely coated with zinc oxide or its resultant salts formed in such an atmosphere. Eventually the iron oxide in the contact chamber became so clogged with this zinc oxide, or to be more exact, with a dry fine white zinc sulphate, that the contact mass had to be removed and fresh material added.

After several weeks of continued effort to make a quantity of acid approaching 10 tons, and almost daily additions of fresh contact material, the entire plant was placed in my hands with instructions to do the best I could. I believe the two chief troubles from a chemical standpoint were the presence of the zinc salts and the use of moist gas. With this belief in mind I conducted a series of experiments, using an ordinary combustion tube wrapped with resistance wire and heated by means of an electric current. The

*Read at the meeting of the American Institute of Chemical Engineers, Pittsburg, Pa., Dec. 28th, 1908.

temperature was easily controlled by external resistance. I was thus able to control the entire operation and observe the effects of moisture and the zinc salt.

In presenting the following data I realize that it contains little or nothing new beyond the possible fact that actual smelter gas was employed. Time did not permit extensive experiments yet I do not believe that the results would be materially altered.

EXPERIMENT A.

Object.—To determine the conversion factor of moist gas. Conducted with a contact mass of well roasted pyrite, a slow current of gas (about 2,000 cc. per minute) undried but thoroughly cleaned by bubbling through water and filtering through asbestos. Ten degrees plus or minus must be granted the pyrometer.

No. of		—Conversion—		
Temp. ° C.	tests.	Max.	Min.	Average
		%.	%.	%.
605	3	37.8	31.9	34.1
610	4	42.6	39.9	41.0
615	6	44.0	42.4	43.2
620	12	43.9	39.0	41.5
625	3	41.5	40.6	41.1
630	2	42.6	42.6	42.6
635	5	39.7	35.6	37.7
640	3	37.9	35.7	37.2

The highest average conversion obtained was 43.2 per cent at about 615 degrees. Further discussion is not called for.

EXPERIMENT B.

Object.—To determine the conversion factor of dry gas. Conducted with a contact mass of the same nature as used in A. The gas thoroughly dried and filtered before subjecting to the contact action. Speed of gas about the same as in Experiment A:

No. of		—Conversion—		
Temp. ° C.	tests.	Max.	Min.	Average
		%.	%.	%.
580	3	29.9	26.3	27.5
585	2	34.7	31.3	33.0
595	1	....	....	48.4
605	1	....	....	49.6
610	6	51.7	49.5	51.0

The highest average conversion of 51 per cent was obtained at about 610 degrees. Further work may have given higher results but lack of time prevented and besides the point in question was satisfactorily demonstrated.

EXPERIMENT C.

Object.—To determine as nearly as experiment would permit, the possibilities of the 10-ton plant under discussion.

Conducted with well roasted pyrite coated with undried furnace gas. It was soon discovered that the flow of the gas had an appreciable effect on the rate of conversion, hence the experiment is divided into three divisions, as shown in the accompanying table.

In experiment C—1 the maximum average was 36.7 per cent. A few experiments with a much slower current of gas gave no higher figures.

In experiment C—2 with about the same speed as in experiments A and B the maximum average conversion was 31.4 per cent, a material drop from that obtained in C—1.

In experiment C—3 the maximum average conversion was 25.9, a still further drop.

It is apparent in these last three experiments that the zinc dust caused a material reduction in the con-

C—1. Flow about 1,000 cc. per minute.

No. of		—Conversion—		
Temp. ° C.	tests.	Max.	Min.	Average
		%.	%.	%.
580	1	....	....	23.3
590	4	25.9	21.8	23.3
610	1	....	....	28.6
615	6	29.9	23.3	27.1
620	5	41.7	31.0	34.8
625	1	....	....	36.7
630	2	31.0	30.7	30.9
640	1	....	....	35.1

C—2. Flow about 2,000 cc. per minute.

No. of		—Conversion—		
Temp. ° C.	tests.	Max.	Min.	Average
		%.	%.	%.
585	2	26.8	24.2	25.5
590	7	25.2	19.5	22.3
595	2	31.4	20.3	25.9
600	4	25.9	23.2	24.5
610	2	23.9	22.1	23.0
615	1	....	....	24.5
620	32	33.9	20.7	27.5
625	2	31.4	31.4	31.4
630	4	32.6	23.3	27.7

C—3. Flow about 3,000 cc. per minute.

No. of		—Conversion—		
Temp. ° C.	tests.	Max.	Min.	Average
		%.	%.	%.
530	1	....	....	9.1
535	1	....	....	8.5
540	1	....	....	9.5
570	1	....	....	5.8
580	1	....	....	15.5
590	2	18.5	16.1	17.3
595	1	....	....	14.5
600	2	15.5	12.1	13.8
610	5	17.3	15.5	16.5
620	14	24.6	20.4	22.2
625	1	....	....	25.9
640	2	12.1	17.7	17.9

version, both as to speed and quantity. As the contact material was of the same nature in all of the experiments it is very evident that the zinc salts did have a retarding influence. As this was practically the only dust that reached the contact chamber, the trouble could not be ascribed to anything else.

To cool the smelter gas, filter to remove the zinc dust, and again heat to the required conversion temperature meant the expenditure of a good many thousand dollars. To further dry the gas would cause a still larger expenditure and a practical rebuilding of the entire plant. As all parts of the apparatus following the contact chamber were in an extremely bad condition owing to the action of the dilute acid on the iron, it was finally decided to abandon the whole undertaking. This decision was later confirmed, after an examination by two competent engineers.

It is well to add that an extremely large chamber plant, designed by the best engineer the country affords, is now under rapid construction and no trouble is anticipated in its operation.

EXHIBIT OF CHEMICAL ENGINEERING APPARATUS AT THE PITTSBURG MEETING OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.

One of the most agreeable and interesting features of the meeting of the American Institute of Chemical Engineers, held in Pittsburg, December 28th and 29th,

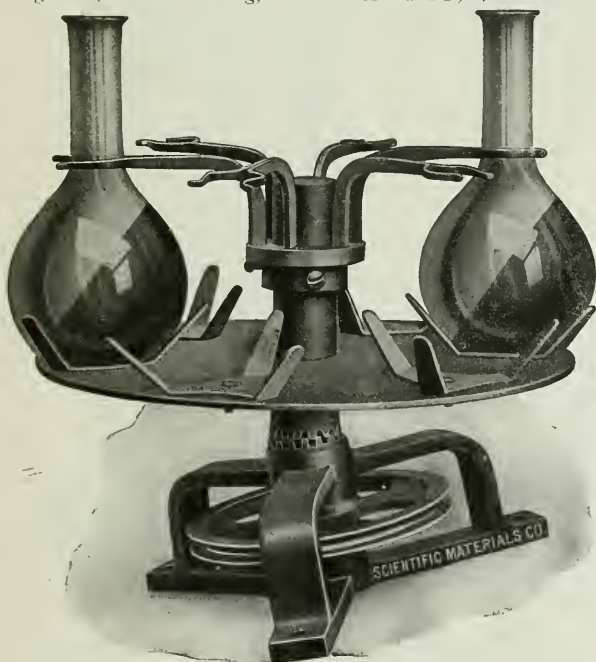


Fig. 1. Camp Automatic Shaking Machine.

visitors of the Institute took a great interest in: the exhibits, and the representatives of the various companies present very courteously explained the various features of their apparatus and installation. A large part of the exhibit naturally consisted of new applications of chemical engineering, and much of this apparatus is therefore of interest to chemical engineers and hence to the readers of THE CHEMICAL ENGINEER. We have, therefore, transferred as much of this exhibit as possible to paper, and present it below for the benefit of our readers:

VULCAN IRON CO., WILKES-BARRE, PA.

The Vulcan Iron Co., Wilkes-Barre, Pa., exhibited a number of photographs showing their rotary kilns for burning cement, nodulizing fine iron ores, etc., and the details of their construction. Among the photographs shown was one illustrating a kiln 8 ft. in diameter by 125 ft. long, resting upon two tires. Other photographs showed the firing hood of this kiln (which fits

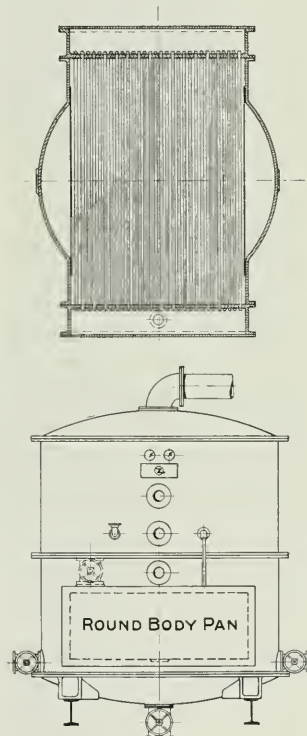


Fig. 2. Zaremba Patent Evaporator (Round Body Pan) Manufactured by the Zaremba Co., Chicago, Ill.

was the exhibit of chemical engineering apparatus, and of drawings and photographs of chemical engineering apparatus and installation, held in connection with this meeting. Some eight or ten firms had their representatives present, and had on view quite a display of appliances for the chemical plant and a large number of well made drawings. The members and

over the lower end). The train of gear used to drive the kiln, the girth gear and method of driving, the idlers on rocker bearings upon which the kiln revolves, and the kiln revolving upon these bearings. Still other photographs showed the kilns in process of erection and a rotary rock drier loaded upon the cars ready for shipment.

SCIENTIFIC MATERIALS CO.

The Scientific Materials Co. had on exhibition the Camp Automatic Shaking Machine (Fig. 1), which was attached to a motor and shown in operation.

This device is intended to be used where agitation is desired in a flask for either dissolving or precipitating, and is particularly adapted for precipitating phosphorus by the molybdic acid method, or for dissolving steels or pig iron for carbon combustion. The shaker is shown in the accompanying cut. The gripping device is movable and will hold six of any size flasks, Florence or Erlenmeyer, from six to twenty-four ounces capacity, any one of which can be placed or removed in a fraction of a second. With each revolution of the machine, a wave travels around each flask, exactly as in hand-shaking, and by increasing or diminishing the number of revolutions the number and intensity of the wave movement is controlled.

The apparatus can be operated by a regular desk fan motor. The inventor of the Shaking Machine, Mr. J. M. Camp, is chief chemist at the Duquesne plant of the Carnegie Steel Co., and is one of the best known metallurgical chemists in the country. The simplicity of the apparatus makes it likely that it will be largely adopted in technical laboratories.

ZAREMBA COMPANY.

Zaremba Company, of 942 Monadnock Block, Chicago, with an Eastern office at 618 Fidelity Bldg., Philadelphia, had on exhibition a model of the Zaremba patent evaporator (round body pan), in which the advantages of the cylindrical shell of the old, so-called, Standard type are combined with the great working capacity of the horizontal heating surface. It is claimed by the maker, that, on account of the improved circulation obtained, the evaporation per square foot of heating surface is 20% greater than in any other submerged-tube type of apparatus.

Fig. 2 shows a front view and also a horizontal cross-section taken through the heating surface. The pans are used in multiple, under vacuum, to form any desired number of effects. They are built in sizes ranging from 30 in. to 14 ft. in diameter.

Zaremba Company also displayed plans of other types of evaporators which they are prepared to furnish for special purposes; such as for the production of high density caustic (1.8 Sp. Gr.); for concentration to crystallization, the product of the evaporator being discharged as crystals, and for the manufacture of salt from brine.

CLEVELAND BRONZE AND BRASS CO.

The Cleveland Bronze and Brass Co. were exhibiting a novel form of valve which will no doubt sooner or later come prominently into the chemical industry. This valve is shown in Fig. 3. The body of the valve is made of a special metal, "Acimet," and is reinforced by a bronze ring cast in the center and supported as shown. The ring is entirely surrounded with "acimet" metal, and makes a strong rigid support for the valve. The yoke is made of cast iron, the stuffing box and the

flange of the same metal, lined with the special alloy. The screw is made of bronze with a four-pitch thread, which makes it quick opening. The valve stem is so constructed that it will not turn, similar to loose disc valves, doing away with the constant friction, and as a consequence, lasting much longer. The valve seats in the same place each time, and this eliminates frictional wear and, of course, prolongs the life of the valve. The flange connections are cast iron, but threaded flanges can be furnished for iron pipe lines. The valve is made in the following sizes, either globe or angle: 1, 1½, 2, 2½, 3 and 4-in.

FULLER ENGINEERING COMPANY.

The Fuller Engineering Company of Allentown, Pa., had on exhibition birds-eye views (see Figs. 4

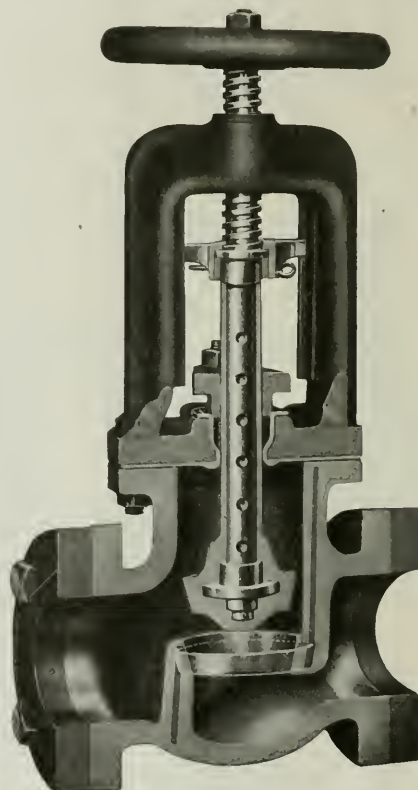


Fig. 3. "Acimet" Valve for Handling Acids Made by Cleveland

and 5) of the cement plants which they have designed, and the construction of which they are supervising for the Seaboard Portland Cement Company, at Alsen, N. Y., and for the Allentown Portland Cement Company, at Evansville, near Reading, Pa. These two plants will unquestionably represent all that is newest and best in cement mill construction. At the Seaboard plant long kilns will be installed, and the burning will be with the Matcham Natural Draft System, in which no fans or other blowing apparatus are needed, and

the pulverized coal is simply sucked into the kiln by the natural draft of the latter. The waste gases from the kiln will also be used to dry both the limestone and the clay, the raw materials from which the cement will be manufactured at this point. The grinding of

long kilns, and with the Natural Draft System of feeding the coal, just as at the Seaboard plant. The grinding will be done by means of the Fuller-Lehigh pulverizer mill. One interesting thing in this connection is the fact that motor drives will be used through-

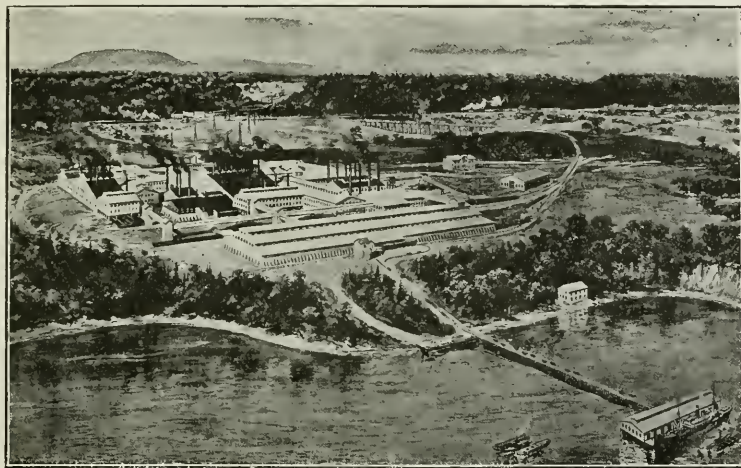


Fig. 4. Birdseye View of the Seaboard Portland Cement Co., Olsen, N. Y., Fuller Engineering Co., Allentown.

the raw materials, the clinker, and the coal will be done with Fuller-Lehigh pulverizers. For the raw material department, ball mills will be used to prepare the raw material for the pulverizers, while on the clinker side rolls will be used. The coal will be dried

out the plant. The Fuller-Lehigh mills will be driven with 75 H. P. vertical motors, thus doing away with quarter twist belts. The power house for the plant will be located several thousand feet from the latter on a level plot of land, near a splendid stream of

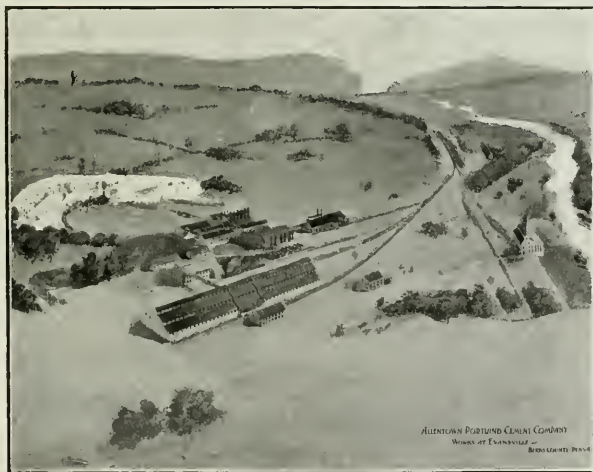


Fig. 5. Birdseye View of the Allentown Portland Cement Co., Evansville, Pa., Fuller Engineering Co., Allentown, Pa.,

in Matcham coal driers. It is estimated that the plant will be in operation in early spring.

The plant of the Allentown Portland Cement Company will utilize for the manufacture of cement, a high-grade limestone and cement rock, which are found on their property. The burning will be done in

water. The clinkers will be cooled in rotary coolers, and the equipment throughout will be the most modern.

The Fuller Engineering Company also had on exhibition a small model of the Fuller-Lehigh Pulverizer Mill, in order to explain to the members its operation

A cut of the mill is shown and a description of its method of working will be found in the article published in this issue by Richard K. Meade, on "The Heating of Industrial Furnaces with Pulverized Coal." In connection with the mill there were also on exhibition a large number of samples, showing the various materials which had been successfully pulverized by the mill. These included a large number of products in which the chemical engineer is interested, such as sand, quartz, gypsum, barytes, foundry facings, etc.

DIDIER-MARCH CO.

The Didier-March Co., with general offices in the Hudson Terminal Building, 50 Church St., New York, had an interesting exhibit which was in charge of Mr. G. S. Hessenbruch, the contracting engineer of the company. This firm has a new plant at Keasbey, N. J., which is devoted entirely to the manufacture of acid-proof chemical-ware. This latter is identically of the same grade and of the same high class as that which is imported from Germany, the reason being that this company used imported raw material for the manufacture of its stone ware. The line which they manufacture is very extensive and consequently it was only possible for them to show a very small part of their products. The exhibit, however, did contain enough to give the members of the Institute an idea of the excellence of their ware: tourills, suction filters, injectors, various kinds of bib and flanged cocks and

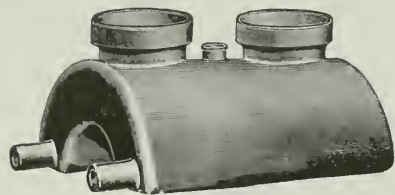


Fig. 6. Cellarius Cell or Tourill.

an acid-proof centrifugal pump being on exhibition. Occupying the center of the exhibit, and possibly attracting more attention than any of the other ware, was the Cellarius cell or tourill shown in Fig. 6. This tourill is a vessel resembling in cross-section a semi-circular arch. On account of its peculiar shape the cell can be immersed up to the gas inlet and outlet socket in cooling water, and the gases in their passage through the apparatus come in contact only with the cooled liquid and the water-cooled surfaces. The absorbing liquid enters through an inlet on the front side of the cell, travels to the end, crosses the saddle in a broad stream and flows along the other side before it escapes through the outlet on the front side, thus traveling twice the whole length of the vessel, and always cooled by contact with the bottom, which stands in cold water. The cell, of course, has a very large surface in proportion to the quantity of liquid it contains. The cell is mostly used in modern hydro-

chloric acid plants, and is so efficient that in a certain plant where it was installed the producing capacity per year was on an average increased 186% and an acid of 23° B $\acute{e}$ was obtained without any difficulty.

Another interesting exhibit was their centrifugal pump. This consisted in an ordinary centrifugal pump having a stone-ware lining and stone-ware impeller. Being encased in metal, it has great strength, while the earthenware lining allows it to be used with strong acids. The pump shown was, of course, of small capacity, but the pump may be obtained to handle as much as 40,000 gallons per hour. The various forms of cocks that were shown were very even in grinding and varied in size all the way from $\frac{3}{8}$ -in. to $2\frac{1}{2}$ in., inside diameter.

This company also exhibited a number of plans of various processes for which the company has the sole right of manufacture in this country. Among them were plans and elevations for a bromine refining apparatus, Guttman's nitric acid condensing plant, Ever's denitrating apparatus (these two latter will be described in our next issue), a storage plant for storing 33 tons of acid, a continuous bromine refining plant, Valentiner system for the manufacture of nitric acid and a hydrochloric acid condensing plant.

THE LEEDS & NORTHRUP COMPANY.

The Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa., had on exhibition a number of resistance pyrometers and also a new recording pyrometer which they have just brought out. This latter is an unusually ingenious piece of apparatus for making continuous records of temperatures of the interior of furnaces. The Leeds & Northrup pyrometers are all of the resistance type. The pyrometer of an indicating or recording type consists of two parts, the fire end, and the indicator or recorder. The fire end bulb consists of a coil of platinum or other resistance wire, enclosed in a tube of some refractory substance, such as porcelain or quartz, protected by a seamless nickel tube. The indicator consists of a Wheatstone bridge, and either a galvanometer or an ammeter. If a galvanometer is used, as is ordinarily the case, the instrument operates off of a dry battery, and by turning an index, the Wheatstone bridge is balanced. The point of balance on the index indicates the temperature. When an ammeter is used, a wall type of instrument results. This is a recent development, and possesses many points of interest.

As we have stated, this is a regular switch-board ammeter, and owing to the strong construction of such, is an instrument which is reliable with long use. It does not have to be delicate, owing to the fact that the use of the ordinary lighting current enables a large amount to be measured. This indicator is supplied with a 5-in., 220°F. scale, and by means of extension plugs the range may be raised to 1,000°F., thereby giving the instrument a scale equivalent to one of 25 in. in length. Owing to this, the instrument

may be checked up to four points throughout its range without disturbing any part of the apparatus. The Wheatstone Bridge is balanced at one point for every 200° of its range, and as most of the measuring is done on this, the ammeter taking only the residual, an error in the latter part of the instrument only effects the measurement of the residual which is only 100. For instance, if the ammeter due to any cause has an error of 3%, the error in the temperature is only 3% of 100, or 3°. If the temperature being measured is 1,800°, the error would be only 3°, whereas with the conventional type of electrical deflection pyrometers this error would amount to 54°. The balance point may be placed at the values which best adapt the instrument to the process for which it is

RECOVERING SULPHUR FROM SMELTER FUMES.

Several methods have been proposed for the recovery of sulphur, which is present as sulphur dioxide from the waste gases of smelters. They are as follows: (1) The separation of the SO_2 gas from the remaining gases by freezing, and the subsequent recovery of the sulphur by reduction; (2) the passing of all the fumes, without separation, through a reducing atmosphere, and by settling or filtering out, recovering the reduced sulphur; (3) the converting of a part of the SO_2 into H_2S , and by a reaction between SO_2 and H_2S , the production of free sulphur; (4) the conversion of the whole of the SO_2 into H_2S , and the production of free sulphur from this by means of the Claus-Chance kiln.

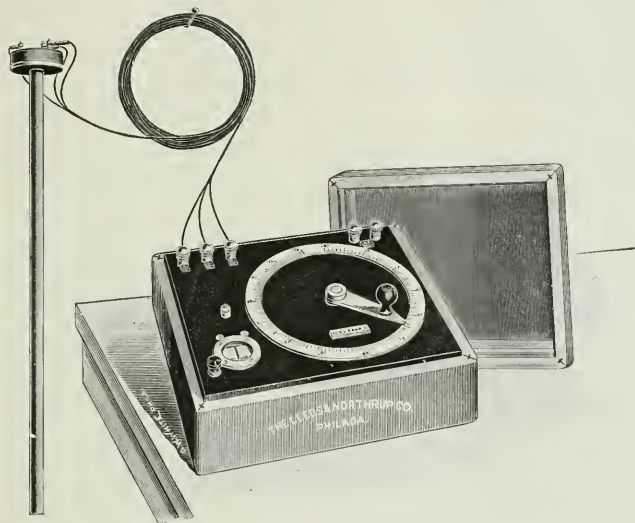


Fig. 7. Resistance Pyrometer. Leeds & Northrup Co., Philadelphia, Pa.

to be used. It will then indicate departures from this temperature so clearly that the workman can stand at some distance from the indicator and easily notice if the furnace or vat is too hot or too cold.

The constancy of the platinum resistance of the fine end, as constructed by the Leeds & Northrup Company, has been tested by the National Bureau of Standards at numerous times over a considerable period of time. Fine ends, which have been out of their factory for some four years, show a change of less than 10°F., after having been steadily exposed to a temperature of about 1,800°F.

These pyrometers have been in use in industrial establishments for some years past, even by men who are unable to read English, and are guaranteed to an accuracy of 500 at 700°F. Fig. 7 shows a Leeds and Northrup pyrometer of the galvanometer type.

(To be continued.)

REFINING SALT.

The process of refining salt practiced near Salt Air, Utah, is a continuous one, the salt being fed to a rotating cylinder about 30 ft. long by 6 ft. in diameter, in the inner part of which is fixed an iron cylinder, about 12 or 16 inches in diameter, charged with superheated steam. An exhaust fan carries off the water vapor, and the fine dust of magnesium chloride and magnesium sulphate. The salt thus treated is not entirely purified, as the magnesia salts are not entirely removed. The salt for table use has to be treated by a second and third grinding, sifting and blowing. The output of salt in the West is stated to be 150,000 to 200,000 tons per annum.

Over one-half the zinc consumed in the United States is used for galvanizing. About one-quarter is used for the manufacture of brass.

THE CHEMICAL LABORATORY

THE VALUATION OF PAINTS.

By RICHARD K. MEADE.

Editor of the Chemical Engineer.

(Continued from January Issue.)

The value of a paint can not be determined by chemical tests alone and for this reason the "strength" test is considered one of the most important tests for pigments.

Strength Test.¹—Weigh out equal portions of the color to be tested, and the standard sample, and to each add equal portions of zinc oxide. Transfer each to a glass plate and rub with a spatula until well mixed. Now take a small portion, first of one then of the other, and rub on ground glass until there is no change in shade on further rubbing. (In the case of Prussian and Chinese blues, greens and blacks, the mixture must be rubbed very hard for some time.) If the two shades are the same the sample is of proper strength.

Whites may be tested in a like manner by comparing the shade of the sample and the standard sample in bleached oil, and by adding to equal portions of each equal portions of some color and treating as above. If the resulting tints are alike the sample is correct.

The relative value of a dry color may also be obtained by making a strength test between it and a sample of known purity, which has the same shade in oil and is made from the same materials. To do this weigh out equal portions of the known and unknown color (the amount will vary with the color and its purity; Chinese and Prussian blue and blacks about 0.2 gms., other colors much more, up to 1 gm., may be taken). Transfer each to a glass plate. Now weigh out two portions of 5 gms. each of zinc oxide, and add to the colors on the glass. Mix as described above and compare the shades on glass. If they are the same their value is the same, but if one is darker than the other add weighed quantities of the zinc oxide until the shades are the same after rubbing out thoroughly. The percentage difference in strength and value may now be determined. For instance: Color No. 1, to which 5 gms. of zinc oxide is added, gives the same shade as color No. 2 with 7 gms. of zinc oxide added. Then color No. 1 is only $\frac{5}{7}$ as strong as color No. 2, and has only $\frac{5}{7}$ of its value plus value of adulteration present.

The Chemical Analysis of Paint.

Mixed White Pigments.

White lead, lead sulphate, zinc, oxide, barium sulphate, barium carbonate, calcium sulphate, calcium carbonate, kaolin, silica, and silicates.

Dry about two grams of the sample for two hours at 105° C. Weigh one gram of this into a small beaker and treat with a mixture of 10 c.c. of acetic acid (95%) and 25 c.c. of water. Boil for a few minutes, filter and wash with hot water. Treat the filtrate as directed in *A* and the residue as directed in *B*.

(*A*). Heat the solution to boiling and pass hydrogen sulphide into the boiling liquid for half an hour. At the end of this time the solution should smell strongly of this reagent. Allow the precipitate to settle and filter. Wash with hot water. Treat the filtrate as directed in *a* and the residue as directed in *b*.

(*a*). Boil off the excess of hydrogen sulphide from the solution and add a few drops of sulphuric acid. This precipitates the barium as barium sulphate. Allow to stand some hours. Filter through a double filter paper, wash with hot water, ignite over a Bunsen burner, and weigh as BaSO_4 . Calculate as barium carbonate $\text{BaSO}_4 \times 0.8455 = \text{BaCO}_3$.

Heat the filtrate from the barium sulphate precipitate to boiling and add ammonia until strongly alkaline and then an excess of ammonium oxalate. Boil a few minutes, allow to settle and filter. Wash with hot water, ignite (using the blast finally) to a constant weight and weigh as calcium oxide. Calculate to calcium carbonate, $\text{CaO} \times 1.7843 = \text{CaCO}_3$.

Magnesia is sometimes found in mixed paints. If it is present, cool the filtrate from the calcium oxalate and add sodium phosphate, ammonium chloride and 20 c.c. of strong ammonia. Stir well. The magnesia if present will be precipitated as MgNH_4PO_4 . Allow to stand over night. Filter and wash with a mixture of 100 c.c. of ammonia, 400 c.c. of water and 50 grams of ammonium nitrate. Ignite over a Bunsen burner (do not use a blast lamp). Cool and weigh as $\text{Mg}_2\text{P}_2\text{O}_7$. Calculate to magnesium carbonate. $\text{Mg}_2\text{P}_2\text{O}_7 \times 0.7575 = \text{MgCO}_3$.

(*b*) Place the filter and precipitate in a large porcelain crucible and ignite until the carbon of the filter paper is all consumed. Brush the residue in the crucible into a small (400 c.c.) beaker and clean out the crucible with nitric acid, pouring the latter from the crucible into the beaker. Add a few cubic centimeters of dilute sulphuric acid (1:1) to the contents of the beaker and evaporate until copious dense white fumes come off. Cool, dilute to 25 c.c. and filter. Wash first with 2 per cent sulphuric acid and then with dilute alcohol until the washings cease to react acid. Discard the alcohol washings. Dry, separate the paper and precipitate, burn the former in a small porcelain crucible, until the carbon is entirely consumed. Moisten the ash with a few drops of nitric acid and add a drop of sulphuric acid. Evaporate to dryness over a low flame and ignite. Cool and add the precipitate to the contents of the crucible. Ignite over a Bunsen burner and weigh as PbSO_4 . Calculate to white lead, $2\text{PbCO}_3, \text{Pb(OH)}_2$. $\text{PbSO}_4 \times 0.85258 = \text{PbCO}_3, \text{Pb(OH)}_2$.

To the cold filtrate from the lead sulphate, add 50 c.c. of a 10 per cent solution of sodium ammonium hydrogen phosphate, carefully neutralize with ammonia, using litmus as an indicator, add a drop or two of ammonia in excess and then acidify with 1 c.c. of acetic acid. Test and make

¹ Hall, "The Chemistry of Paints and Paint Vehicles."

sure the solution is acid. Heat (do not boil or bumping will result) for one hour, during which time the precipitate will become granular and settle. Filter through a filter paper, wash with hot water and dry the paper and precipitate. Brush the latter off the former onto a watch glass, dissolve the small amount of precipitate upon the filter in dilute nitric acid into a small weighed porcelain dish. Evaporate to dryness, add the main portion of the precipitate and ignite, gently at first and finally for a few minutes at a low red heat. Cool and weigh as $\text{Zn}_2\text{P}_2\text{O}_7$. Calculate as ZnO . $\text{Zn}_2\text{P}_2\text{O}_7 \times 0.2671 = \text{ZnO}$.

(B) Boil the residue from the acetic acid treatment with 20 c.c. of hydrochloric acid (1:1) and 5 grams of ammonium chloride for 5 minutes and dilute to 400 c.c. Digest a few minutes, filter and wash with hot water. Treat the filtrate as directed in *c* and the residue as in *d*.

(c) Precipitate the lead in the solution with hydrogen sulphide as directed in A. Allow to settle, filter and wash. Dissolve the precipitate in nitric acid. Place the solution in a weighed porcelain dish and evaporate to dryness, after adding a few drops of sulphuric acid. Ignite gently and weigh as PbSO_4 . Report as such.

Heat the filtrate from the lead sulphate to boiling. Add ammonia until strongly alkaline and precipitate the lime as oxalate as directed in *a*. Calculate as calcium sulphate. $\text{CaO} \times 2.4271 = \text{CaSO}_4$.

Note.—Should a slight precipitate form on addition of the ammonia, it is alumina. Filter this off, ignite, weigh, and report as Al_2O_3 . Precipitate the calcium in the filtrate with ammonium oxalate.

(d) Ignite the insoluble residue in a platinum crucible and weigh. After weighing, fuse this insoluble residue with ten times its own weight of sodium carbonate. Extract the fusion with hot water, filter and wash. Dissolve the residue in 5 c.c. of dilute hydrochloric acid, dilute, boil, and add a few drops of sulphuric acid. This precipitates any barium which was present as sulphate in the paint. Allow to stand some hours, filter through a small double filter paper, wash and ignite over a Bunsen burner. Weigh as BaSO_4 . Report as such. Deduct from the weight of the insoluble and report the difference as clay, silica, and insoluble silicates.

ANALYSIS OF INDIVIDUAL WHITE PIGMENTS.

White lead may be tested for adulteration by the method of analysis outlined for "Mixed White Paints."

Lead-zinc white, sometimes contains zinc sulphate. To determine this, boil one gram of the sample with 75 c.c. of water and 25 c.c. of alcohol, filter and wash with a mixture of alcohol and water (1:3). Add 3 c.c. of dilute (1:1) hydrochloric acid to the filtrate and heat the latter to boiling; add an excess of barium chloride to the solution and allow to stand some hours. Filter, wash well with hot water, ignite and weigh as BaSO_4 . Calculate to zinc sulphate. $\text{BaSO}_4 \times 0.6916 = \text{ZnSO}_4$.

To determine lead oxide, lead sulphate and zinc oxide, proceed as follows: Weigh one gram of the sample into a 10-oz. beaker and heat with a mixture of 10 c.c. of water, 10 c.c. of hydrochloric acid (conc.) and 5 grams of ammonium chloride for five minutes. Dilute with hot water to

400-500 c.c. and boil for a few minutes. (If there is a residue, filter it off, ignite, and weigh it and report as "insoluble.") Heat the filtrate to boiling and add 20 c.c. of barium chloride and proceed as above, for zinc sulphate. Call the weight of BaSO_4 obtained "total sulphate." Deduct from this the BaSO_4 found above in determining the zinc sulphate. Calculate the difference to lead sulphate and report as such. $\text{BaSO}_4 \times 1.2077 = \text{PbSO}_4$.

Treat another sample with 20 c.c. of strong nitric acid and 100 c.c. of water. Add 5 c.c. of dilute sulphuric acid (1:1) and evaporate until dense white fumes come off and proceed to determine lead and zinc as in *b*. Deduct from the lead sulphate found here (which represents total lead) the lead sulphate (and insoluble, if any is present) as found above, and calculate the difference to lead oxide. Report as such. $\text{PbSO}_4 \times 0.7357 = \text{PbO}$. Calculate the zinc found here (which represents total zinc) to zinc oxide. Also calculate the zinc sulphate found previously to zinc oxide. ($\text{ZnSO}_4 \times 0.5035 = \text{ZnO}$.) Subtract the latter amount from the former. The difference represents the zinc oxide.

Zinc Oxide.—This may be analyzed by the scheme outlined above for lead-zinc white, or the total zinc may be found by any of the standard methods used for determining zinc in zinc ores, etc.

Whiting should contain no free lime. To test for this, boil a sample with water and add phenol phtalein solution. If a red color is produced the presence of free lime or other alkali is shown.

Barytes may be tested by boiling 1 gram of the sample with 10 c.c. of dilute hydrochloric acid (1:1) for ten minutes; then diluting to 100 c.c., again boiling and filtering. The filtrate may be tested for Fe_2O_3 , Al_2O_3 , CaO , MgO , etc. The residue consists of barium sulphate and silica. Ignite and weigh. Moisten the residue in the crucible with a few drops of dilute sulphuric acid and add a little hydrofluoric acid. Evaporate to dryness. Ignite gently for some time over a Bunsen burner and weigh. The loss in weight represents silica.

To test for soluble sulphates (CaSO_4), boil 1 gram as above with 10 c.c. of hydrochloric acid, dilute, filter and wash. Determine the sulphate in the filtrate by precipitation with barium chloride and calculate the barium sulphate to calcium sulphate.

(To be continued.)

In a determined effort to secure still greater economy in the use of coal and at the same time to reduce the smoke nuisance, the Pennsylvania railroad has instituted a special campaign of education among its engineers and firemen. A general order has just been sent out all over the lines east of Pittsburg to the effect that "smoke means waste and must be avoided." The company has five assistant road foremen of engines at work in and near Pittsburg, instructing firemen with a view to reducing the quantity of smoke emitted by engines. The coal bill of the road last year was about \$10,000,000. More efficient handling of coal will result in a saving to the company of \$100,000 annually.

THE STANDARDIZATION OF POTASSIUM PERMANGANATE SOLUTION AND ITS SUBSEQUENT USE IN TITRATING IRON.¹

By CORNELIS OFFERHAUS AND ERNST H. FISCHER.

The following notes are a brief account of our experience with standards for the potassium permanganate solution. Although the accuracy of the standardization of this solution, which is extensively used for the valuation of industrial products, is of great importance, a suitable unassailable standard substance has been known only for a comparatively short time. Among the principal standards still in use, are Mohr's salt, oxalic acid, with or without water of crystallization (Hempel; Clemens Winkler) and iron, in the form of soft iron wire. The first three substances are hard to obtain pure and to keep constant; the last one contains impurities. Treadwell² shows that it is wrong to assign to the soft iron wire its iron content (less than 100 per cent) as iron value, as is generally done. In comparing it with electrolytic iron as to its reduction value to a potassium permanganate solution, it is found that the impurities of the soft iron wire, have a greater reduction power than the iron itself and that its iron value is over 100 per cent. Treadwell recommends determining the iron value of a large quantity of soft iron wire by comparing it with electrolytic iron as to its reduction value to a permanganate solution, and to use the soft iron wire for subsequent standardization, applying the iron value thus obtained. He prepares the electrolytic iron, using Classen's method³ and in such quantities as to just suffice for one titration. Skrabal⁴ condemns Treadwell's proposition, as total oxidation of the carbides does not take place. He oxidizes the impurities entirely by allowing the solution of the soft iron wire to stand in a warm place over night with an excess of a warm permanganate solution. He then reduces with zinc and hydrochloric acid and standardizes, assigning to the soft iron wire its iron contents as iron value. Lunge⁵ doubts the purity of electrolytic iron, as it may contain carbon and it may hold hydrogen in occlusion. He recommends determining the iron value of the soft iron wire with pure soda, using a hydrochloric acid solution, a barium hydroxide solution, an oxalic acid and a permanganate solution as intermediate solutions. The weak points of his suggestion are the acidimetric use of a weak acid (oxalic acid) and the many solutions and titrations it involves.

The only suitable and unassailable standard for oxidimetry, existing at the present time, is sodium oxalate, proposed by Sorensen.⁶ This was originally recommended by Sorensen as a standard for acidimetry, although the possibility of its use as a standard for oxidimetry was mentioned by him. We possess, however, in soda a very suitable standard for acidimetry and the value of sodium oxalate therefore lies mainly in its use as a standard for oxidimetry. It was introduced rapidly as such in Europe,

but it seems that it is not as yet sufficiently known in this country.

The pure salt as sold by Kahlbaum under the name of "Sodium Oxalate Sorensen" is made as prescribed by Sorensen. It contains no water of crystallization, is not hygroscopic and can be dried to 150° C. and higher, without alteration.

We compared this sodium oxalate "Sorensen" with electrolytic iron "Burgess" to determine their suitability to serve as standards for the permanganate solution. An analysis of this electrolytic iron shows the following impurities:

	Per cent.
C	.00
Si	.003
P	.004
S	.002
Mn	.020

A sufficiently aged, approximately tenth-normal permanganate solution was used, burette and weights were carefully calibrated, temperature corrections were made and the rapidity of the flow of the solution was kept as constant as possible; in short, all precautions were taken to avoid the usual errors. Iron and sodium oxalate were dissolved to 50 c.c. and taken in such quantities that about 45 c.c. of the permanganate solution was used for each titration. The electrolytic iron was dissolved in 50 c.c. of ten per cent sulphuric acid solution in an apparatus as described in Classen's "Ausgewählte Methoden der analytische Chemie," Band 1, p. 449. Some sodium bicarbonate was added to expel the air from the 100 c.c. flask. In performing the operation one notices the following advantages in the use of sodium oxalate over that of iron: (1) the operation of dissolving is simpler and much faster; no time is lost in cooling the solution; (2) oxidation by the air is not to be feared and the completion of the reaction is much more distinct.

The following are the results we obtained for the same permanganate solution, in using the two substances under discussion, the figure given being in each case the factor for converting the volume of solution used to the volume of tenth-normal solution which would have been required:

Sodium Oxalate "Sorensen."	Electrolytic Iron "Burgess."
0.00324	0.98809
0.00336	0.98802
0.00291	0.98840
.....	0.98808

Average, 0.99317 Average, 0.98860

One notices that the coefficients obtained with sodium oxalate are higher and show a better concurrence than those obtained with electrolytic iron.

In burning sodium oxalate, sodium carbonate is obtained and this is a means of using sodium oxalate as a standard for acidimetry as proposed by Sorensen, and to compare it with pure soda, Lunge's standard for acidimetry, which years of use have proven to be correct.

¹ Electrochem. Ind., Vol. II., p. 138.

¹ School of Mines Quarterly.

² "Lehrbuch für analytische Chemie," Band 11., p. 72.

³ A. Classen, Quantitative Analyse, durch Electrolyse. (See also Chemical Engineer, Vol. II., p. 281.—Editor.)

⁴ Skrabal, Ztschr. anal. Chem., 42, p. 359.

⁵ Lunge, V. Int. Kongr. f. angew. Chem.

⁶ Zeltschr. f. analyt. Chem., 1897, p. 639, pp. 333, 512.

The following are the average factors which we found in standardizing an approximately N/5 solution of hydrochloric acid with pure sodium carbonate, dried at 300° C. and with sodium oxalate, using methyl-orange as an indicator:

Sodium Carbonate.	Sodium Oxalate "Sorensen."
1.00092	1.00121

The sodium oxalate was burned in a platinum crucible. To prevent loss by sputtering the crucible was kept covered at the start and a small flame was applied. The flame was gradually raised and the carbon burned off. The soda was not fused. It was found unnecessary to burn or filter off the carbon entirely. The above figures do not show a practical difference, which confirms the statement of Sorensen, that sodium oxalate can be used as a standard for acidimetry and puts it on a solid basis as a standard for oxidimetry. So far our results confirm the statement of Treadwell, that the impurities of iron have a higher reduction value than the iron itself (note the lower factor of the electrolytic iron "Burgess") and prompt us to recommend sodium oxalate "Sorensen" as a standard for oxidimetry in preference to the electrolytic iron.

Electrolytic iron should only be preferred in titrating iron and then only if it could be procured pure.

Perhaps the most important use made of the permanganate solution is for titrating iron in iron ores and the Zimmerman-Rheinhardt method* is generally used for this purpose, being the most rapid one.

A solution should be standardized under conditions as nearly similar to those under which it is to be used for determinations as possible. Accordingly we standardized the permanganate solution, following the Zimmerman-Rheinhardt method, with electrolytic iron "Burgess" and with sodium oxalate "Sorensen"; e. g., in standardizing with sodium oxalate the solutions of the Zimmerman-Rheinhardt method were also added. The operation was performed and solutions of a concentration were used as given in Treadwell's "Analytische Chem.," Band 11.

The following table gives the coefficient of the permanganate solution, standardized with the two standards in question, as given above, and using Zimmerman-Rheinhardt's method:

Sodium Oxalate "Sorensen."	Electrolytic Iron "Burgess."
Zimmerman-	Zimmerman-
Rheinhardt's Method, Direct.	Rheinhardt's Method, Direct.
0.98318	0.97796
0.98418	0.97584
0.98238	0.97294
0.98325 average	0.97558 average
Dif. 0.00092	Dif. 0.01302

The factors obtained with sodium oxalic show also in this case a better concurrence than those obtained with electrolytic iron and the difference of factor is practically the same in both cases, the obtainable accuracy of the Zimmerman-Rheinhardt method taken in consideration.

In standardizing the permanganate solution for subsequent use to titrate iron in iron ores according to Zimmerman-Rheinhardt, it is seen we may advantageously use sodium oxalate in the place of electrolytic iron.

The titration in this case must be performed cold and the reaction takes place rather slowly at the start, but this is of minor importance since oxidation by the air does not take place.

DETERMINATION OF VANADIUM, MOLYBDENUM CHROMIUM AND NICKEL IN STEEL.¹

By ANDREW A. BLAIR.

Analytical Chemist, Philadelphia, Pa.

Dissolve two grams of the sample in nitric acid with the addition of hydrochloric acid, if necessary, evaporate to dryness, redissolve in hydrochloric acid and evaporate until the solution is sirupy. Dissolve in a small amount of hydrochloric acid (1.1 Sp. Gr.), cool in ice water and wash into a separatory funnel of about 250 c.c. capacity, with as small an amount as possible of acid of the same strength. The separatory funnel should be conical in shape and should be fitted at the lower end with a Geissler stop-cock and at the upper end with a glass stopper. Both stopper and stop-cock should be most carefully ground to prevent leakage. Add to the solution in the funnel about 80 c.c. of ordinary ether and shake vigorously for half a minute. An ordinary clamp with cork-lined jaws supported on a stand makes a convenient arrangement for holding the funnel. When the two strata have separated, open the stop-cock and allow the lower to run into another separatory funnel. Remove the stopper, wash the solution down with about 10 or 15 c.c. of hydrochloric acid (1.1 Sp. Gr.), shake again and allow the washings to run into the other funnel. Add 50 c.c. of ether to the solution in the second funnel to remove as much of the remaining iron as possible, run the acid solution into a beaker and evaporate nearly to dryness. Add nitric acid in excess and evaporate until all the hydrochloric acid is expelled and finally when the solution is almost sirupy, add 20 c.c. of hot water. Heat the solution and add a few drops of sulphuric acid to reduce any chromic acid that may have been formed. Boil and pour the solution slowly, stirring vigorously, into a boiling solution of sodium hydroxide containing 100 grams sodium hydroxide to the litre. Boil the solution for a few minutes, allow the precipitate to settle, filter, wash twice by decantation and finally on the filter until the filtrate measures about 300 c.c. in volume. The precipitate consists of the oxides of chromium, nickel and iron, with the greater part of the manganese and any copper that may have been in the sample. The filtrate contains the vanadium, some silica and alumina from the sodium hydroxide and sometimes a little chromium. Add dilute nitric acid to the filtrate until it just turns blue litmus paper red, then add a few drops of sodium hydroxide solution to make it alkaline, boil and filter. To the filtrate add 10 c.c. of a 10 per cent solution of lead nitrate and then enough acetic acid to make it decidedly acid, and boil for several minutes. Filter the precipitate which contains all the vanadium as lead vanadate and wash with hot

* C. Reinhardt, Stahl u. Eisen, 1884, p. 709; Chem. Ztg., 1889, p. 323.

¹ J. Am. Chem. Soc., August, 1908.

water. Dissolve in hot dilute hydrochloric acid, evaporate nearly to dryness, add 50 c.c. of hydrochloric acid and evaporate again, add 10 c.c. of strong sulphuric acid and evaporate until it fumes freely. Allow it to cool and when cool, dilute to 150 c.c.; heat to a temperature of 60° or 70° and titrate with permanganate. The iron value of the permanganate solution multiplied by 0.0157 gives the vanadium. The method of reducing vanadium by evaporating with hydrochloric acid and then driving off the hydrochloric acid with sulphuric as proposed by Campagne¹ gives most excellent results. The presence of small amounts of iron does not affect its accuracy and the trouble of boiling off every trace of sulphurous acid when this reagent is used is avoided.

The two precipitates obtained from the sodium hydroxide solution contain chromium, nickel and copper, besides iron and manganese. Ignite the two filters and precipitates and fuse with about two grams of sodium carbonate and half a gram of potassium nitrate. Treat the fused mass with water and filter. The insoluble portion contains the chromium and the rest of the manganese. To the filtrate add ammonium nitrate in sufficient quantity to change all the sodium salts to nitrates and evaporate to a small bulk, adding a few drops of ammonia from time to time. Dilute to about 50 c.c., boil, filter, and wash with hot water. The insoluble matter consists of manganese and any silica, alumina, etc., that may have been in the reagents. Boil the filtrate to drive off the ammonia, add sulphurous acid to reduce the chromic acid, boil off the excess and precipitate by ammonia. Filter, wash, ignite and weigh the chromium sesquioxide, which contains 68.46 per cent of chromium.

Return the filter, containing the insoluble matter from the fusion, to the crucible in which the fusion was made, ignite, dissolve in hydrochloric acid, dilute precipitate the copper by hydrogen sulphide, filter and evaporate the filtrate with excess of sulphuric acid until the hydrochloric acid is expelled. Dilute, add excess of ammonia and precipitate the nickel by electrolysis. A current of about four and a half amperes is sufficient and the iron and manganese present do not interfere with the accuracy of the results.

To the ethereal solution of the iron, which remains in the two separatory funnels, add water and shake. Draw off the ferric chloride containing the molybdenum, which separates from the ether and evaporate nearly to dryness, add 10 c.c. strong sulphuric acid and evaporate carefully until the hydrochloric acid is driven off and the sulphuric acid fumes freely. Cool, dissolve in about 100 c.c. of water and carefully deoxidize with ammonium bisulphite, boil off the excess of sulphurous acid and cool the solution. Transfer the cold solution to a pressure bottle of 200 c.c. capacity and pass a current of hydrogen sulphide through it until it is saturated, close the bottle and heat it on a water bath for several hours. Allow it to cool slowly. Filter on a Gooch crucible, wash the precipitate first with water containing a little sulphuric acid and finally with alcohol. Place the Gooch crucible containing the precipi-

tate on a small triangle placed inside a large porcelain crucible so that the bottom of the Gooch crucible shall not touch the porcelain crucible. Cover the latter with a watch glass and heat it carefully, raising the heat gradually until there is no smell of sulphurous acid. Replace the watch glass with a porcelain cover and heat until the precipitate of molybdenum sulphide becomes bluish white in color.

Place the Gooch crucible over a lamp and heat it to faint redness, cool and weigh. Heat it again to faint redness, weigh and repeat the operation until it ceases to lose weight. Place the crucible on the vacuum flask and dissolve the molybdic trioxide in dilute ammonia, wash, heat and weigh the crucible. The difference between the two weights is molybdenum trioxide which contains 66.67 per cent molybdenum. There always remains on the felt in the Gooch crucible a small amount of ferric oxide.

BROMINE MANUFACTURE IN OHIO.

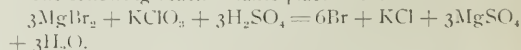
After the salt has been removed from the grainers the remaining liquid, known as bitter and having a density of from 35° to 40° B., is run into a tank, where it settles. It is then conducted to a still, the body of which is made of sandstone.

The bitter and chemicals are poured into the still through a funnel shaped opening in the top and withdrawn from the still by a small opening in the bottom, after the bromine has been removed. Steam is blown into the still by a small opening in the bottom, producing a temperature reported at about 180° F.

The condenser is simply a rectangular box about 5 feet long, through which pass three lead pipes extending from the still at one end to the bottle which collects the bromine at the other. Cold water is kept running through the box, condensing the bromine.

The bromine exists in the bitter as magnesium bromide ($MgBr_2$), comprising about one-half of 1 per cent of the mass. After bitter has been run into the still and steam turned in sulphuric acid (H_2SO_4) as added, the proportion being 1 pound of the latter to 20 gallons of the former. This is followed by the addition of potassium chlorate ($KClO_3$), the ratio being 1 pound to 60 gallons of bitter.

The following reaction takes place in the still:



The bromine escapes as a gas, but is changed to a liquid in the condenser.

Formerly manganese dioxide (MnO_2) was used in place of the potassium chlorate, the change resulting from the lower cost of the latter.

The short fiber is used for the manufacture of wall plaster and pipe coverings. Walls plastered with this material dry quickly and have a smooth, glossy surface which is strictly fireproof. The short fiber is also used as a fireproof packing in stoves and ranges to prevent the radiation of heat from the sides. The long fiber is used in the manufacture of asbestos cloth and board.

¹ Compt. rend., 127, 570 (1902).

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

PUBLISHED MONTHLY BY
THE CHEMICAL ENGINEER PUBLISHING COMPANY
355 Dearborn Street, Chicago

Entered as Second Class Matter, Aug. 19, 1907, at the Post Office at Chicago, Illinois, March 3, 1879.

Subscription—United States, Cuba and Mexico \$2.00
Extra postage to Canada 25c a year, to foreign countries 50c a year.
Remittances may be made by check, draft, or money order in favor of
THE CHEMICAL ENGINEER PUBLISHING CO.

All matter connected with subscriptions or advertising should be sent to
The Chemical Engineer Publishing Co., 355 Dearborn street, Chicago.
Anything intended for the Editorial Department should be sent directly
to the Editor, Richard K. Meade, Nazareth, Pa.

NOTES AND COMMENTS.

TESTED REAGENTS.

A communication from Prof. Edward Hart, of Lafayette College, criticizing so-called tested chemicals, is published elsewhere in this issue. This is after all largely a matter of taste, and Prof. Hart undoubtedly expresses the opinion of a certain number of chemists. The tested chemical is very much like a chemical analysis, it all depends on the man who is making it. We think it very probable that some tested chemicals are not what they pretend to be. On the other hand, we know that there are tested chemicals which are what they represent themselves to be, and it is altogether a matter of the veracity of the manufacturer and the analytical skill of his chemist. We question, also, if the word "guarantee" would really mean any more. A guarantee is much like the test, in that it all depends on the man who makes it. As to whether the customer is justified in taking the manufacturer's analysis in place of one which he makes himself, we have always entertained some doubt, although here again, as is above said, it is largely a case of the reliability of the manufacturer and the skill of his analyst. There is this fact, however, about, not only most of the tested chemicals, but indeed most manufactured articles, that they can usually be depended upon not to be any better than the claims their makers put forward for them; and if the analysis on the bottles shows the chemical to contain a larger percentage of the impurity than the analysis to be made with it would warrant, the chemist is of course warned that he *must* test the reagent. However, the whole question sums up in a nutshell, there are *good* reagents which do not claim to be tested and there are *good* reagents whose makers honestly believe that they are as good as the label on the bottle specifies, and this opinion is backed by the skill of as good a chemist as they can afford to employ.

INTERNATIONAL ATOMIC WEIGHTS, 1909.*

The report of the International Committee on Atomic Weights, consisting of Professors F. W. Clarke, W. Ostwald, T. E. Thorp and G. Urbain (ap-

pearing in the January issue of the *Journal of the American Chemical Society*) contains numerous though for the most part unimportant changes from former tables.

Urbain, a French chemist, and Auer von Welsbach, of Vienna, have proved that Ytterbium is a mixture of two elements which Urbain names "neoytterbium" and "lutecium," and Welsbach calls "aldebaramium" and "cassiopeium." Urbain having the priority, his names are preferred by the committee, and are used in the report. Eighty-one elements are now recognized by the committee, the latest addition being lutecium, mentioned above and neoytterbium, which takes the place of ytterbium.

Commenting on the changes the committee say: "In their report for 1908 this committee recognized the fact that a general revision of the atomic weight table was desirable, and such a revision has now been made. Modern investigations have shown that the fundamental values required modification, and through

INTERNATIONAL ATOMIC WEIGHTS, 1909.

Atomic		Atomic	
	Symbol, Wght.		Symbol, Wght.
Aluminum	Al 27.1	Molybdenum	Mo 96.0
Antimony	Sb 120.2	Neodymium	Nd 144.3
Argon	A 39.9	Neon	Ne 20.0
Arsenic	As 75.0	Nickel	Ni 58.68
Barium	Ba 137.37	Nitrogen	N 14.01
Bismuth	Bi 208.0	Osmium	Os 199.9
Boron	B 11.0	Oxygen	O 16.00
Bromine	Br 79.92	Palladium	Pd 106.7
Cadmium	Cd 112.40	Phosphorus	P 31.0
Cæsium	Cs 132.81	Platinum	Pt 195.0
Calcium	Ca 40.09	Potassium	K 39.10
Carbon	C 12.00	Praseodymium	Pr 140.6
Cerium	Ce 140.25	Radium	Ra 226.4
Chlorine	Cl 35.46	Rhodium	Rh 102.9
Chromium	Cr 52.1	Rubidium	Rb 85.45
Cobalt	Co 58.97	Ruthenium	Ru 101.7
Columbium	Cb 93.5	Samarium	Sa 150.4
Copper	Cu 63.57	Scandium	Sc 44.1
Dysprosium	Dy 162.5	Selenium	Se 79.2
Erbium	Er 167.4	Silicon	Si 28.3
Europium	Eu 152.0	Silver	Ag 107.88
Fluorine	F 19.0	Sodium	Na 23.00
Gadolinium	Gd 157.3	Strontium	Sr 87.62
Gallium	Ga 69.9	Sulphur	S 32.07
Germanium	Ge 72.5	Tantalum	Ta 181.0
Glucium	Gl 9.1	Tellurium	Te 127.5
Gold	Au 197.2	Terbium	Tb 159.2
Helium	He 4.0	Thallium	Tl 204.0
Hydrogen	H 1.008	Thorium	Th 232.42
Indium	In 114.8	Thulium	Tm 168.5
Iodine	I 126.92	Tin	Sn 119.0
Iridium	Ir 193.1	Titanium	Ti 48.1
Iron	Fe 55.85	Tungsten	W 184.0
Krypton	Kr 81.8	Uranium	U 238.5
Lanthanum	La 139.0	Vanadium	V 51.2
Lead	Pb 207.10	Xenon	Xe 128.0
Lithium	Li 7.00	Ytterbium	
Lutecium	Lu 174.0	(Neoytterbium)	Yb 172.0
Magnesium	Mg 24.32	Yttrium	Y 89.0
Manganese	Mn 54.93	Zinc	Zn 65.7
Mercury	Hg 200.0	Zirconium	Zr 90.6

them many other atomic weights are affected, although the changes thus brought about are less important than they were generally supposed to be. Many atomic weights remain practically unaltered, and in few instances are the changes large, as a comparison of the new table with its predecessors will show. A careful scrutiny of all the evidence was, however, none the less necessary, and the table now offered gives the results thus obtained.

*On the inside of the back cover will be found this table, printed in large type and suitable for a wall chart for the laboratory or office.—Editor.

"The fundamental atomic weights, the standards of reference employed in the calculations, are as follows, when O = 16:

H	1.008	Br	79.916
C	12.000	Ag	107.880
N	14.007	K	39.095
Cl	35.463	S	32.070

"The value for silver is possibly a trifle too low, by three to five units in the third decimal place. A combination of the best measurements gives Ag. = 107.883. In this case, and in others as well, the second place of decimals is given in the table, the third place being uncertain. Thus we have K 39.10, N 14.01, Br. 79.92, etc. Only with hydrogen is the third place retained."

CHEMICAL SOCIETIES.

AMERICAN CHEMICAL SOCIETY.—W. R. Whitney, Pres.; Charles L. Parsons, Sec'y, Durham, N. H.

SOCIETY OF CHEMICAL INDUSTRY, NEW YORK SECTION.—George C. Stone, Pres.; H. Schweitzer, Sec'y, 128 Duane St., N. Y. City. NEW ENGLAND SECTION.—Henry Howard, Pres.; Alan A. Clafflin, Sec'y, Box 1189, Boston, Mass.

WESTERN ASSOCIATION OF TECHNICAL CHEMISTS AND METALLURGISTS.—W. G. Swart, Pres.; H. C. Parmelee, Sec'y, P. O. Box 1421, Denver, Colo.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Charles B. Dudley, Pres.; Edgar Marburg, Sec'y, Univ. of Penn'a, Philadelphia, Pa.

AMERICAN ELECTROCHEMICAL SOCIETY.—E. G. Acheson, Pres.; J. W. Richards, Sec'y, Bethlehem, Pa.

AMERICAN LEATHER CHEMISTS' ASSOCIATION.—H. T. Wilson, Pres.; H. C. Reed, Sec'y, Stamford, Conn.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—Samuel P. Sadler, Pres.; John C. Olson, Sec'y, Polytechnic Institute, Brooklyn, N. Y.

AWARDING OF THE PERKIN MEDAL.

At the regular meeting of the New York Section of the Society of Chemical Industry held at the Chemists' Club on Friday evening, January 22, the Perkin Medal for 1909 was presented to Dr. Arno Behr in recognition of his valuable discoveries tending toward the promotion of the corn products industry.

The meeting opened with a few introductory remarks by the chairman of the section, Mr. Maximilian Toch, and with the report of the committee for the presentation of the Perkin Medal, by Dr. Hugo Schweitzer. Prof. Charles F. Chandler made the presentation address and Dr. Behr acknowledged receipt of the medal. Mr. T. B. Wagner then delivered an address on "The Great American Industry of Corn Products," after which the meeting closed with remarks by Mr. Wm. H. Nichols.

Dr. Behr made his reputation as chemist for the old Matthiesen & Weichers Sugar Refinery, and subsequently in the early eighties went to Chicago and erected a glucose works. Later he developed a process for the crystallization of grape sugar. Again he revolutionized the corn industry by isolating the germ, expressing the oil and finding uses for corn oil.

WESTERN ASSOCIATION OF CHEMISTS AND METALLURGISTS.

The fourth general meeting of the Western Association of Technical Chemists and Metallurgists was held at Boulder, Golden, and Denver, Colorado, January 6, 7 and 8. The session Wednesday was held in the Chemical lecture room of the University of Colorado, at 7 p. m., after an inspection of the laboratories and shops of the university. The meeting was opened with an address of welcome by James H. Baker, president of the university. This was followed by the following five papers: "Electrochemistry of Essler's Equation," J. B. Ekeley and A. L. Tatum; "A Direct Volumetric Method for the Determination of Aluminum," W. H. Seamon; "Theory of the Dry Chlorination of Sulphide Ores," F. W. Traphagen; "A Proposed Basis for the Settlement of Mine Leasing," W. H. Davis; "A Demonstration of a Rotating Anode Electrolytic Apparatus," A. L. Tatum. The session at Golden was held Thursday evening at 8 o'clock, in the Stratton Metallurgical Hall of the Colorado State School of Mines, after an inspection of Coors' Golden Brewery and of the laboratories and shops of the State School of Mines. The following four papers were read at this session: "Notes on Metallurgy" (with demonstrations), W. G. Haldane; "The Separation of Vanadium by Means of Sodium Peroxide," H. F. Watts; "A Critical Discussion of the Analytical Methods of Estimating Vanadium," W. F. Bleecker; "Calculations in Ore Concentration," Rudolf Gahl; and a general discussion of "How Can the Bureau of Standards Assist the Chemical and Metallurgical Professions?" Friday morning was given over to an excursion to the Globe plant of the American Smelting and Refining Co., at Globeville, Colo. In the afternoon the association visited the plant of the Western Chemical Manufacturing Company. At night the annual banquet was held at the Hotel Albany, at which time the president, W. G. Swart, delivered his annual address, and the reports of the other officers were read. The headquarters of the association during the meeting were in Denver, and the members left for Boulder and Golden in the afternoons of Wednesday and Thursday respectively.

The officers for the ensuing year are as follows: President, W. D. Engle, University Park, Colo.; secretary and editor, H. C. Parmelee, Denver; treasurer, J. W. Root, Denver; librarian, W. G. Vail, Denver.

AMERICAN CHEMICAL SOCIETY.

The thirty-ninth meeting of the American Chemical Society was held in Baltimore from Tuesday, December 20 to Friday, January 1. The attendance was the largest at any previous meeting of the society, more than 400 chemists being present. The sessions were held at the various institutions in Baltimore. The general meetings were all held in the assembly hall of the Girls' Latin High School. The sections with the exception of the the biological met at the Woman's College. The biological section met at the Johns Hopkins Medical School. At the general session the following

addresses were delivered: "The Function of Chemistry in the Conservation of Our Natural Resources," M. T. Bogart; "Science Teaching as a Career," H. P. Talbot; "The Untilled Field of Chemistry," A. D. Little; "The Use and Abuse of the Ionic Theory," Gilbert N. Lewis; "The Work of Werner on the Constitution of Inorganic Compounds," Chas. H. Herty; "The Future of Agricultural Chemistry," H. J. Wheeler; "The Quantitative Study of Organic Reactions," S. F. Acree; "The Classification of Carbon Compounds," Edward Kremers; "The Efficiency and Deficiencies of the College Trained Chemist When Tested in the Technical Field," Wm. H. Nichols; "To What Extent Should College Training Confer Practical Efficiency Along Technical Lines?" Louis M. Dennis; "The Attitude of Technical Institutions to Post-Graduate Study," Wm. McMurtrie.

Over one hundred and sixty papers were announced and read before the nine different sections into which the meeting was divided. Many of the papers provoked considerable discussion, notably those for the Division of Industrial Chemists and Chemical Engineers. At this latter section the following papers were read: Walter O. Snelling, "The Munroe Crucible"; Percy H. Walker and H. A. Whitman, "Rapid Analysis of Babbitt Metal"; Chas. H. Herty and W. S. Dickson, "The Unsaponifiable Matter in the Oleo-Resins of Conifers"; Allerton S. Cushman, "Acceleration Tests of the Resistance to Corrosion of Iron and Steel"; David W. Day, "The Changes in Crude Petroleum Effected by Diffusion through Clay"; George Auchy, "Further Remarks on Vanadium and Its Estimation"; Paul N. Clancy, "Iron, from a Chemical and Commercial Standpoint"; C. H. Ehrenfeld, "An Unusual Incrustation on Generator Coils"; W. H. Walker, "Principles Underlying Efficient Grinding and Separating"; H. J. Skinner, "The Purchase of Material on Specification"; F. A. Olmstead, "Some Industrial Applications of the Ives Colorimeter"; C. F. Woods, "Factors Determining the Efficiency of Trolley Wires"; E. W. Boughton, "The Iodine Number and some other Values for China Wood Oil"; E. G. Bailey, "Accuracy in Sampling Coal"; W. D. Richardson, "The Storage of Beef at Temperatures Above the Freezing Point"; "Observations on the Freezing Out of Colloids with Reference to Frozen Meats"; "Observation on Certain Stains Applied to Frozen and Unfrozen Muscular Tissue"; "Frozen Poultry"; and "Observations on the Best Methods of Cold Storage"; Charles E. Munroe, "The Commercial Manufacture of Amorphous Calcium Phosphide," and "The Distribution of Nitrate of Soda in the United States"; L. A. Olney, "Standard Methods for Determining and Recording the Relative Permanency of Resistance of Coloring Matters to the Common Color Destroying Agencies"; A. G. Stillwell, "Standardization of Methods for Commercial Analysis of Fats, Greases, etc., and Adoption of Rational Nomenclature for Same"; Theodore Whittlesey, "Guayule and Guayule Rubber"; Arthur Lowenstein, "The Rapid Determination

of Moisture in Commercial Products of a Viscous or Semi-Solid Consistency"; C. F. Mabery, "Lubrication and Lubricants."

The local committee had made special arrangements for the entertainment of visiting chemists, consisting of a banquet and a smoker, with automobile rides, parties and dinners for the attending ladies. Excursions were made to Annapolis, to the Maryland Steel Company's works, to the various Baltimore breweries, to Sharp & Dohrue's Chemical Works, and to various points of interest around the city.

Dr. W. R. Whitney, director of the Research Laboratories of the General Electric Company, has been elected president for the ensuing year. Prof. Noyes and Mr. Richardson are continued as editors of the society's two journals and Dr. Hallock and Prof. Parsons as treasurer and secretary respectively. The new directors are: W. L. Miller, C. H. Herty, S. W. Parr and W. H. Walker.



Willis Rodney Whitney, Ph. D.,

President of the American Chemical Society.

Born Jamestown, N. Y., Aug. 22, 1868. Educated at the Massachusetts Institute of Technology (B. S., '90) and at Leipzig (Ph. D., '94). Instructor of Chemistry, Massachusetts Institute of Technology, 1895 to 1900, and assistant professor, 1901 to 1904. Since 1904 director of the Research Laboratory of the General Electric Company, Schenectady, N. Y. Originator of the "electrolytic theory" of the corrosion of iron.

Thin aluminum foil is used largely for packing purposes in place of lead and tin, its non-poisonous properties making it particularly suitable for this purpose, while it has the advantage over tin in point of price.

CORRESPONDENCE.

Combustion.

What is the latest definition of "combustion," also state whether the rusting of iron could be considered as such accordingly.

Webster defines combustion as "the operation of fire on an inflammable material; burning." The Standard dictionary defines combustion as "to be on fire." These definitions seem to the editor to define very clearly combustion. Both the burning of a substance in air, and the rusting of iron are chemically the same reaction. On the other hand, it is possible to burn oxygen in an atmosphere of hydrogen, while it would be impossible to rust iron under such a condition. The term "burning" as ordinarily used may be considered as a phase of rapid oxidation. Late researches indicate that the rusting of iron is an electro-chemical phenomenon and not merely a simple case of the union of iron with oxygen. We can, of course, burn iron when finely divided in an atmosphere of either oxygen or air, and the product will, of course, be rust, but we should hardly say in this instance that the iron had rusted, but rather that it had oxidized.

Concerning Tested Chemicals.

Editor of THE CHEMICAL ENGINEER:

Sir: In "The Prima Donna" Marian Crawford informs us that in the New York market one may buy eggs, fresh eggs and strictly fresh eggs. This reminds one of the brands hydrochloric acid, hydrochloric acid, C. P., and hydrochloric acid strictly C. P. The latter term is also, I believe, a New York invention. Of late we have had a new development of this peculiar American trait in the Tested Chemicals, also spelled with capital letters. There is, however, one word which would be effectual legally which singularly enough is absent from all such announcements: that is the word "guaranteed."

Sensible and honest practice, if the customers would allow it, would be to call a pure article by the chemical name simply. If this were done hydrochloric acid would mean the purest article that could be made commercially. Ordinary hydrochloric acid would be labeled "Commercial" or "Contains Sulphuric Acid," or some other appropriate form of words. But C. P. has come to mean something commercially, and manufacturers cannot do this if they would.

Tested chemicals are a new form of deceit and one that has worked harm, because few people worry themselves to think. In the factory, pure chemicals are made up in batches, sometimes large, sometimes small, depending upon the demand. If the manufacturer is skillful and his help good the quality of the product is good. The batch is then usually sampled and tested by the chemist for purity. And here let me say that chemists engaged in this work often become very skillful and can give Krauch points. For commercial reasons they do not always reveal their

methods. Any manufacturer will give the customer the benefit of this analysis and be glad to do so. But he cannot guarantee the analysis and so make himself legally liable, because employees of all sorts sometimes make mistakes and they will even lie occasionally; and so it does happen sometimes in spite of constant vigilance that impure articles are sent out. The most common cause of trouble is in the operation of bottling, where nothing but a constant watch and the *co-operation of the customer* is effectual in detecting the careless workman.

It is thus evident that it is necessary that the customer shall frequently himself examine what he buys. Any attempt on the part of the manufacturer to do this for him must be ineffectual, and if it were effectual would invite fraud on the part of the unscrupulous. Some of these days the tested chemicals will be the subject of scrutiny on the part of the Food and Drugs Commission and it will be discovered that some of the beautiful labels giving elaborate analytical detail have not been changed often enough.

EDWARD HART.

INDUSTRIAL AND PLANT NEWS.

Babbitt. The Brighton White Metal Co. of New Brighton, Pa., has been formed and will manufacture babbitt metal, solder, linotype metal and tin plate metal. A building has been leased and will be remodeled and equipped for manufacturing purposes at once. W. D. Berry, of the Brighton Brass and Bronze Co., of New Brighton, Pa., is at the head of the new concern and J. S. McMaster will be general manager.

Brass Foundry. Mitchell & Van Meter will erect at Pottstown, Pa., a one story brass foundry, 40x75 feet. J. V. Poley, C. E., Royersford, Pa., is preparing the plans.

Brewery. E. G. Nicely and other capitalists will erect a brewery to cost about \$35,000 at Somerset, Pa. An engineer will be selected at once to prepare the plans, and work will be started in the spring.

Carborundum. The Carborundum Co., F. W. Haskell, president, will enlarge its plant at Niagara Falls, N. Y., by erecting a four story factory structure, 225x60 feet.

Cement. The Niagara Cement Co. is having plans prepared for an extension to its manufacturing plant along the Buffalo River, to cost \$250,000. The offices of the company are at 892 Ellicott Square Building, Buffalo, N. Y.

Chemicals. A plant for the manufacture of chemicals and pharmaceutical products is to be built at Memphis, Tenn., by the Wm. A. Webster Co. The plant will cost \$200,000. W. C. Kerstann, of Chicago, Ill., is general manager of the company.

Coke. The coke oven interests of the American Coal Products Co. were turned over, January 1, to the German American Gas Co. The capital of the new company will be \$2,000,000.

Fertilizers. The merger of independent fertilizer interests has been financed by J. P. Morgan & Co. Some forty companies located throughout the southern Atlantic states are interested as well as potash interests of Waldemar Schmidtman in Germany. The output of the company will be about 1,000,000 tons and the capital stock will be \$50,000,000, equally divided between common and preferred stock.

Foundry. The T. H. Symington Co. of Corning, N. Y., and Baltimore, Md., will erect at Rochester, N. Y., a

foundry to manufacture miscellaneous malleable iron castings. The cost of the plant will be about \$800,000. E. John Nichols is secretary of the company, Corning, N. Y.

Foundry. The Lynchburg Foundry Co., H. E. McWane, president, owning pipe works at Lynchburg and Radford, Va., has purchased a site at Norfolk, Va., with deep water frontage, on which to build a modern pipe foundry for export and coastwise trade.

Glass. The Johnstown Stained Glass Co., Wm. Heslop & Son, owners, has been incorporated with a capital of \$50,000. The company has purchased a site at 435 Lincoln St., Johnstown, Pa., where it will erect a two story manufacturing plant equipped with the latest machinery. The construction will be begun this spring.

Grape Juice. A corporation in which R. J. Moorhead is interested with a capital of \$500,000 has been formed to build and operate a grape juice factory at Warren, Pa.

Iron. It has been announced that Dr. G. B. Crowe and other capitalists have purchased a site at Bessemer, Ala., near the United States Cast Iron Pipe and Foundry Co. and will soon begin work on the erection of four plants. The first of these will be a fire-brick plant which will be followed by a coke plant of 250 ovens. In this latter the gas from the coke ovens will be utilized for power purposes. Two blast furnaces with a capacity of from 250 to 300 tons daily will also be built. The total expenditures will amount to from \$750,000 to \$1,000,000.

Iron. It is stated that the River Furnace & Dock Co., a new corporation organized by Corrigan, McKinney & Co., will begin the erection of two furnaces to cost \$2,000,000 at Cleveland, Ohio. The plant will be located on the upper river section and work will be begun as soon as the weather permits.

Paint. The Charles A. P. Barrett Paint Co. of Dayton, Ohio, has increased its capital stock from \$100,000 to \$150,000. It is stated that the company will remove its factory from Troy, where it has been located for several years, to Dayton, Ohio, building a new factory at the latter place.

Paper. The Spokane Paper & Pulp Co., capitalized for \$1,000,000, is being organized by C. H. Pride, president of the Tomahawk Paper & Pulp Co., Tomahawk, Wis., and will erect a plant to cost \$850,000 at Spokane, Wash., in the early spring. A pulp mill is also to be built in northern Idaho.

Paper. The Oxford Paper Co. is building an addition to its plant at Rumford Falls for the manufacture of bleach liquor and caustic soda by an electrolytic process. The electric machinery is to be built by the Western Electric Co. and the power is to be supplied by the Rumford Falls Power Co.

Paper. The Yellow Pine Paper Co. of Orange, Texas, will treble the present capacity of its plant, giving it a daily output of 25 tons. E. S. Farwell, C. E., 309 Broadway, New York, is preparing the plans. The cost of improvements, including machinery and buildings, will amount to about \$150,000.

Paper. The Marathon Paper Mills Co. has been organized by capitalists of Wausau, Wis., to build a fifty-ton paper mill near Wausau.

Paper and Pulp. Whitney and Son, of Philadelphia, Pa., are to build a pulp mill to cost \$4,000,000, near Bryson City, N. C. The company will cut 200,000 feet daily and employ about 2,500 men.

Paper and Pulp. The Gordon Pulp and Paper Co. had built at Dryden, Ont., a forty-ton sulphite plant. The company has at this point on the Wabigoon River a water-power of 46 ft., capable of producing 5,000 H. P. The entire equipment of machinery and apparatus will be

supplied by the Stebbins Engineering & Manufacturing Co., of Watertown, N. J.

Pharmaceutical Chemicals. It is reported that John Wyeth & Bros., Philadelphia, Pa., intend to enlarge their plant at 12th and Washington streets by a three story addition, to cost \$100,000.

Plaster. The Olympic Plaster Co., it is stated, has secured a site at Seattle, Wash., and will erect there a factory equipped with the latest machinery for the manufacture of wall plaster, etc.

Portland Cement. The Victor Portland Cement Co. will build a plant with a daily capacity of 3,000 barrels at Victorville, Cal., to cost about \$1,000,000. Plans have been prepared and work will begin at once.

Portland Cement. It is stated that a cement plant will be erected in Bushkill, Pa., to manufacture 1,000 barrels a day and cost approximately \$300,000. Water power will be utilized from Winona Falls.

Portland Cement. It is announced that the Marquette Cement Manufacturing Co., 204 Dearborn St., Chicago, Ill., will increase the capacity of its plant by over 50 per cent, bringing the daily output to the total of 6,000 barrels.

Shot. The Union Metallic Cartridge Co. will erect a 10 story factory building to cost approximately \$150,000 at Bridgeport, Conn., for the manufacture of shot of all sizes. The factory will have a capacity of 100 tons a day.

Soap. Thomas Hersom & Co. will locate a soap factory at Acushnet, near New Bedford, Mass.

Steel. The New York State Steel Co., which has been in the hands of receivers for about a year, has been reorganized with a capital of \$3,500,000, an increase of \$1,000,000 preferred stock, which will be used principally to complete the company's blast furnace and auxiliary works located on the Buffalo River, near Buffalo, N. Y.

Steel. The West Penn Steel Co. will erect a plant to cost \$500,000 at Tarentum, Pa. There will be an 80-ton furnace and it is expected that the plant will be practically complete by the early spring.

Steel. The Superior Iron & Steel Co. of Warren, Ohio, has been incorporated by C. F. Clapp of Warren, Ohio, O. E. Kreuger and others with a capital of \$300,000 to operate a plant at that place.

Steel. The West Penn Steel Co. of Pittsburg, Pa., is erecting at Tarentum, Pa., a plant for the making of steel, such as is used for electrical apparatus, steel furniture, automobiles, etc. The plant will consist of an 80-ton open hearth basic furnace; bar mill with soaking pits and full mechanical equipment; three sheet mills, equipped complete with two stands of cold rolls, etc. The cost of the plant will be about \$500,000.

Steel. According to the daily papers the United States Steel Corporation is to build a \$14,500,000 plant in the spring at a point on the St. Louis River, three miles from Superior, Wis. The blast furnaces are to be on the Minnesota side of the river, but auxiliary plants are to be located on the Wisconsin side. Sixteen hundred acres of land have been purchased and cleared, and plans have been drawn for not only the construction of the furnace, but also an industrial city, similar to that at Gary, Ind.

Tin Plate. It is stated that the U. S. Steel Corporation, 71 Broadway, N. Y., will double the plant of the American Sheet & Tin Plate Co. at Morgantown. When complete the plant will represent an investment of \$1,000,000 and will employ 1,000 people.

Tungsten Lamp. It is reported that a plant for the manufacture of the tungsten lamp is to be erected by the National Lamp Co. of Warren, Ohio, at that place.

Wood Pulp. A wood pulp mill with a capacity of 10 tons daily will probably be erected at Seminary, Miss., by John W. Berg of Mobile, Ala.

RECENT INVENTIONS.

The following patents relating to applied chemistry and metallurgy are reported for THE CHEMICAL ENGINEER by C. L. Parker, attorney in chemical patent causes, 908 G street, N. W., Washington, D. C.:

905,232. *Copper and Process for Purifying, Casting and Alloying the same.* August J. Rossi, New York, N. Y., December 1, 1908.

The method consists in incorporating with the copper while molten, a titanic material in quantity sufficient to free the resulting product from undesired compounds and gases.

905,280. *Metallurgical Process.* Anson G. Betts, Troy, N. Y., December 1, 1908.

The process consists in recovering a metal or metals including zinc by reacting on a material containing oxidized zinc with silicon.

905,384. *Varnish and Manufacture Thereof.* Frank R. Suter, New York, N. Y., December 1, 1908.

The process consists in introducing molasses, from which most of the water has been eliminated by boiling, into melted resin, and then adding to the mixture a distillate of asphalt diluted with a suitable vehicle.

905,115. *Process of Manufacturing Ammonia.* Frederick W. Frerichs, St. Louis, Mo., December 1, 1908.

The process consists in distilling off the ammonia and volatile ammonium compounds from ammoniacal liquors, combining the same with acid sulphate of ammonium for making neutral sulphate of ammonium and decomposing the neutral sulphate of ammonium by heat into free ammonia gas and acid sulphate of ammonium.

905,602. *Process of Dehydrating Moist Chlorine.* Elmer A. Sperry, Brooklyn, N. Y., December 1, 1908.

The process consists in refrigerating the gas in a plurality of chambers, thereby producing chlorin hydrate in such chambers, disconnecting a part of such chambers from the system and treating the contents of such disconnected chambers for the separation of chlorine and water.

905,785. *Electrolytic Solution for Zinc Plating.* Celestino Blanco, New York, N. Y., December 1, 1908.

The electrolytic contains compounds of zinc and iron and an organic acid salt of an alkali metal.

905,943. *Preparation of Casein.* Emilio Soncini, Milan, Italy, December 8, 1908.

The process consists in adding sulphur dioxide to skimmed milk until the casein contained therein is precipitated and separating the precipitate thus formed from the whey.

906,102. *Art of Producing Pigments by Electrolysis.* Edwin D. Chaplin, Boston, Mass., December 8, 1908.

The process consists in electrolytically separating an electrolyte into a solvent of lead and an alkaline hydrate, dissolving metallic lead by said solvent thereof, electrolytically producing an oxidizing agent and adding the same to the resulting soluble salt of lead to prevent the formation of insoluble salts of lead, withdrawing said soluble salt of lead, withdrawing and carbonating said alkaline hydrate, thereby producing an alkaline carbonate and then directly carbonating said soluble salt of lead with said alkaline carbonate to produce white lead.

906,202. *Composition of Matter to be Used for the Welding of Copper.* James Crew, Charleston, W. Va., December 8, 1908.

The composition consists of borax, carbonate of iron and alum.

906,306. *Process for Vulcanizing a Rubber Solution.* Hermann Scherpe, Duren, Germany, December 8, 1908.

The method consists in mixing a solution of rubber in tetrachloride of carbon with a solution of iodine in tetrachloride of carbon.

906,173. *Method of Treating Aluminum Silicate.* Frank J. Tone, Niagara Falls, N. Y., December 8, 1908.

The method consists in mixing with aluminum silicate an amount of carbon insufficient to reduce all the silicon, and subjecting the mixture to electrically developed heat sufficient to reduce a portion of the silicon and to fuse the alumina-silica residuum into a hard refractory abrasive material.

906,321. *Process of Preparing Merchantable Iron from Tin Plate Scrap.* Elmer A. Sperry, Brooklyn, N. Y., December 8, 1908.

The process consists in compacting the scrap in laminated bundles, treating the bundles with mechanical stress in line of the laminations, for opening up the interstices of the bundles, and recompressing such bundles at right angles to the laminations.

906,338. *Process of Producing Silicon.* Frank J. Tone, Niagara Falls, N. Y., December 8, 1908.

The method consists in forming a mixture of aluminum silicate and carbon sufficient to reduce the silicon to its elementary form, and insufficient to reduce the aluminum, said mixture being substantially free from iron-containing and basic metalliferous materials, subjecting this mixture to electrically developed heat sufficient to reduce the silicon and to fuse the alumina, and then separating the elemental silicon from the alumina.

906,383. *Solder for Aluminum and Other Metals.* Charles G. Carroll and William H. Adams, Fayetteville, Arkansas, December 8, 1908.

The solder consists of calcium and tin, said calcium being in sufficient quantity so as to reduce the aluminum or other metallic oxides on the surfaces of the metals to be soldered as to allow of the adherence of such solder.

906,627. *Process of Uniting Metals.* Everett D. Holley, Forestville, and Charles L. Root, Bristol, Conn., December 15, 1908.

The process consists in applying a coat of melted zinc to the surface of the iron, and then pouring the copper in melted condition into the zinc coated-surface of the iron and allowing it to cool naturally.

906,637. *Aluminum Solder.* Harry B. Lambert, North Pelham, N. Y., December 15, 1908.

The composition consists of tin, zinc, antimony and phosphorus used for the purpose of soldering aluminum to aluminum and aluminum to other metals.

906,793. *Process of Producing Gas.* Charles J. Greenstreet, Alton, Ill., December 15, 1908.

The method consists in introducing limestone and a carbonaceous matter into a retort, subjecting said retort to heat and injecting steam into said retort.

906,883. *Process of Desulphurizing Ores.* Robert Hubner, New York, N. Y., December 15, 1908.

The process consists in subjecting the ore to heat while keeping it out of direct contact with the heating agent and exerting suction to withdraw gases from the chamber containing the ore while keeping said chamber otherwise closed to prevent the entrance of any material amount of air.

906,916. *Process of Japanning Metal Surfaces.* Patricio Oramas, New York, N. Y., December 15, 1908.

The process comprises first coating the cleaned surface of the articles with a black or other colored varnish, screening a layer of bran over the varnished surface, subjecting it to a temperature increasing gradually from 50° C to 150° C., and lastly polishing the same.

907,608. *Method of Making Artificial Slate.* Robert Kesler, Philadelphia, Pa., December 22, 1908.

The method consists in mixing together a slow hardening cement, coloring matter, hair, lime and water, heating the resulting mass until it has a uniform consistency and then pouring it into molds.

The Chemical Engineer

PUBLISHED BY

The Chemical Engineer Publishing Co., 355 Dearborn St., Chicago

Vol. IX.

MARCH 1909.

No 3.

THE MANUFACTURE OF BISULPHITE OF SODA.

BY ROBERT KANN,

Research Chemist, Perth Amboy, N. J.

The raw materials employed in the manufacture of bisulphite of soda are commercial soda ash, manufactured by the Solvay process and obtained in the market at a strength of 58% Na_2O , and brimstone. The soda ash is usually obtained in bags of 300 lbs. each, and is dumped into a round iron tank situated conveniently on the top floor of the building. The dissolving tank is equipped with a mechanical stirrer and a single steam coil closed at the end with a cap and placed on the bottom of the tank. The coil is fitted with holes 12 inches apart from each other. It is preferable to use condensed steam water for dissolving the soda ash, if such can be obtained; if not, city water will answer. The dissolver has a capacity of about 350 cu. ft.; about 20 bags of soda ash equal to 6,000 lbs., can be dissolved in three hours. The tank has an opening of 3 inches diameter at the bottom, with which is connected a short piece of iron pipe and a stop cock to allow rapid discharge of the solution after it is made up to the desired strength. The soda solution is made of a density of 6°Bé less than the desired solution of bisulphite of soda; thus a solution of sodium carbonate of 30°Bé is prepared if the desired bisulphite of soda solution is supposed to test 36°Bé .

The finished soda solution is run into settling tanks. The capacity of each settler is 350 cu. ft. The thorough settling and cooling requires about 12 hours. On the sides of each settling tank, about 6 inches from the bottom, is placed a stop cock connected with a short piece of pipe of 3 inches diameter, to allow discharging the clear solution by gravity into covered troughs leading to the saturating tanks, which are placed below the settlers and are made in series of two. In front of each saturator is a scrubber, and adjoining, at the end, is a so-called after-tank. In constructing, it is cheapest to build one large wooden box and divide into six compartments. The scrubber, saturator and after-tank are lined with lead, which is braced by means of narrow iron plates, covered with lead, placed about 15 inches apart from each other and soldered to the walls.

Fig. 1 shows the arrangement of the saturating process. Sulphur dioxide gas obtained by burning

brimstone in a sulphur burner enters first the scrubber to be freed from sulphur trioxide and dust, and then goes through the saturator, which is filled with the soda solution, and the excess finally passes into the after-tank, which is also filled with soda solution to retain the gas. When the solution in the after-tank is sufficiently saturated with sulphur dioxide gas, it is transferred to the saturator and new solution is placed into the after-tank. Below is a detailed description of the apparatus as shown in Fig. 1.

A. The scrubber is filled two-thirds full with water and is 4 feet long, 6 feet wide and 6 feet deep. The cast iron pipe, B, is flanged at *a* to a lead pipe, *h*, which reaches almost to the bottom of the tank. The portion of the lead pipe outside the scrubber from *a*

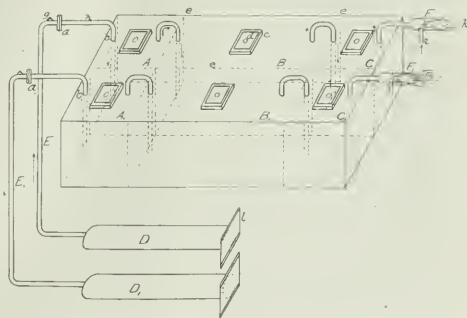


Fig. 1—Arrangement of Saturating Apparatus.

to *b* is inclosed in a lead jacket, through which water circulates to cool the gas before entering the scrubber.

B. The saturator tank is 10 feet long, 6 feet wide and 6 feet deep, and is filled two-thirds with soda solution. The available capacity is 240 cubic feet.

C. The after-tank is of the same size as the scrubber.

The tanks are separated by wooden partitions, *c, c*, covered with lead.

Each tank is equipped with a manhole, *c*, covered with a lead lined cover, bolted to the sides of the manhole. The lid also has a two-inch hole, *d*, which is closed by a wooden plug; the opening is used for filling and emptying.

D is the sulphur burner, consisting of a cast iron pipe 10 feet long by 2 feet diameter, equipped with a

sliding door, *l*. The sulphur dioxide passes through the cast iron pipe *E*, which is flanged to a lead pipe, *h*. The cast iron pipe is about 15 feet high and has a diameter of 6 inches; on each end it is closed by a plug, *g*, which is removed when the pipes are cleaned.

F. The steam blower, which is made out of lead, carries the gas through the saturating system. Steam enters at *i* and the steam and CO_2 escape at *k*.

The sulphur burners are very efficient and easy to operate; about 1,500 lbs. of brimstone can be burned in each burner in 24 hours. The sulphur dioxide gas enters first the scrubber which serves to catch all dust and sulphur trioxide before entering the saturator through another lead pipe. The saturation requires about 36 hours. One thousand eight hundred gallons of bisulphite of soda solution can be produced in each saturator in 36 hours. The excess of sulphur dioxide gas which increases toward the end of the saturation is caught in the after-tank *C*, which is also filled two-thirds with soda solution. This solution must be renewed as soon as the sodium carbonate is neutralized. The carbon dioxide set free during the process passes in the air through the nozzle of the steam blower, which is placed on top of the after-tank. The water in the scrubber tank must be renewed as soon as it becomes saturated with sulphur dioxide. The finished solution of bisulphite of soda is syphoned with a rubber hose, which is placed through the 2" hole in the manhole cover, into a covered storage tank, or could be filled directly in whisky barrels with good joints, but should not be stored in barrels, as they start to leak if the solution is kept in them too long.

In constructing a plant the arrangement of setting the tanks is best made by selecting a building which has a height of about 40 feet, in order to deliver the solutions from one operation to the other by gravity; but if it is desired to install a plant in a building which has not the specified height the arrangement can be so

cess of air and light. The process requires very little labor. The steam from the exhaustor can be condensed and used for dissolving soda ash.

The diagram, Fig. 2, indicates the arrangement for a plant where the solutions are conveyed entirely by gravity, while in the arrangement shown in Fig. 3 a pump is employed.

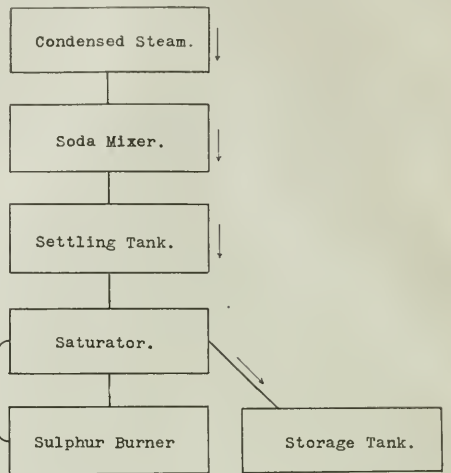


Fig. 2—Arrangements Where Solutions Are Conveyed by Gravity.

CHEMICAL CONTROL OF THE PROCESS.

The following methods of analysis will be found very convenient and exact for the examination of the different materials used for the manufacture of bisulphite of soda, the intermediate and finished products.

a. Soda Ash. An average sample is taken from every lot of soda ash and assayed for Total Na_2O , insoluble matter, NaCl and Na_2SO_4 .

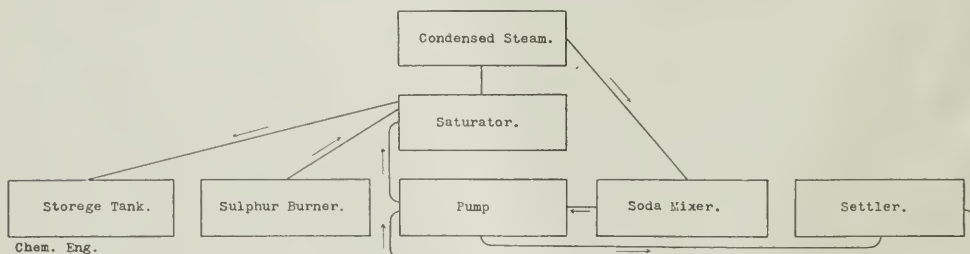


Fig. 3—Arrangement Where Pump Is Employed.

made that the soda mixer and the settling tank are situated on the main floor and the saturator on the floor above. In this case a total height of 20 feet will be sufficient; the soda solution is pumped from the mixer to the settling tank by means of a centrifugal pump and the same pump is used to convey the solution from the settler to the saturator. It is of importance that the finished solution be protected from ex-

Dissolve 20 grammes of the sample in hot water, filter through a tared gooch crucible, filter into a 500 c. c. beaker, and wash thoroughly with hot water, dry and weight crucible and contents; the difference between the first and second weight is "Total Insoluble Matter." Transfer the filtrate and washings to a 1,000 c.c. graduated flask, cool and fill up with water to the graduation mark and mix well.

Total Na_2O . Place a 50 c.c. portion in a 300 c.c. titrating flask, add 100 c.c. water and 2 drops of a solution of methylorange and titrate with a standard solution of hydrochloric acid of which 1 c.c. equals 0.02 gram Na_2O .

NaCl . Measure 250 c.c. of the solution in a 600 c.c. beaker, add 15 c.c. of a solution of nitric acid (1:1), and then add drop by drop a solution of nitric acid (1:5) till exactly neutral, now add a few drops of potassium chromate solution and titrate with a neutral solution of silver nitrate of which 1 c.c. equals 0.005 grams NaCl .

Na_2SO_4 . Transfer 250 c.c. to a 500 c.c. beaker, add hydrochloric acid (1:1) till neutral and afterwards 10 c.c. in excess, bring to boil and precipitate with 10 c.c. of a boiling solution of barium chloride, boil the mixture till precipitate begins to settle and keep on a warm place till perfectly clear, filter, wash with hot water, dry, ignite precipitate and filter paper in a porcelain crucible and weigh as BaSO_4 .

b. BRIMSTONE. An average sample is taken from every lot and assayed for moisture and ash by the following method:

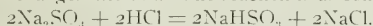
Moisture. Weigh out 20 grams of the powdered sample in a tarred weighing bottle and dry to constant weight in a steam dryer. The difference between original and last weight is moisture.

Ash. Place 5 grams of the sample in a large porcelain crucible and ignite carefully under a hood, using a very small flame at first to avoid running over. Increase the flame gradually and heat the crucible until no more vapors are given off, cool crucible and weigh the residue.

BISULPHITE OF SODA. A sample is taken from every lot of the finished product from the saturator by means of a long glass tube reaching almost to the bottom of the tank and the following ingredients are determined.

NaHSO_3 . Place 25 c.c. of the solution in a 250 c.c. graduated flask, fill up to the mark with water, mix well and take a 25 c.c. portion from the flask, place in a 300 c.c. titrating flask, dilute with water to about 150 c.c., add 2 drops of phenolphthalein solution and titrate with a half normal standard solution of sodium hydrate till a pink color appears.

Free Na_2SO_3 . Place 25 c.c. of the original sample in a 300 c.c. flask, add about 150 cc. of water and two drops of a solution of methylorange and titrate with a standard solution of hydrochloric acid till the yellow color changes into red. The reaction is as follows:



As a rule, free Na_2SO_3 is only present in traces. This is a simple test to determine whether the saturation is complete.

Fe . Measure 100 c.c. of the original solution in a 400 c.c. beaker, add 15 c.c. strong nitric acid, boil for a few minutes, cool, add ammonia, boil and filter off the precipitated ferric hydrate, dry, ignite precipitate and filter in a porcelain crucible and weigh as Fe_2O_3 .

Iron is usually present only as traces, if larger quan-

ties are found the quality of the product is inferior.

Specific Gravity is determined with a hydrometer.

SOLUTION FROM AFTER-TANK. Sample the solution from after-tank every time a charge is drawn from the saturators, or as soon as any sulphur dioxide gas is noticed to escape through the exhaustor. The specific gravity should be over 30° Bé and the solution should be only slightly acid. Determine NaHSO_3 as described above.

Wash-Water in Scrubber Tank. Assay for total acidity by titrating 10 c.c. of the sample diluted with 150 c.c. of water with the same standard solution as used for determining NaHSO_3 . Use phenolphthalein as indicator and calculate as SO_2 . Take a sample after every finished charge of bisulphite of soda.

The following process is given in *The Metal Industry* as being suitable for the metalizing of wood:

The wood is first coated with two or three very thin coats of orange shellac prepared by dissolving 2 ounces of shellac in 1 pint of wood or denatured alcohol. This coating protects the wood against action of the solutions used in the process. When the shellac is thoroughly dry apply a very thin coat of turpentine, copal varnish or hard oil finish. Allow to dry for a short time; when "tacky," dust over a coat of pure copper bronze powder with a camel's hair brush, care being taken to completely cover the wood with the powder. A second application should be made with a stiffer brush so that the coat becomes perfectly smooth. The wood when perfectly dry is then ready for plating. Make up a solution of—

Sulphate of copper..... 2 lbs.

Sulphuric acid 4 ozs.

Water 1 gal.

Dissolve in hot water and allow to cool. Use anodes of pure copper.

A bill is now before Congress to authorize the purchase by the government of a huge testing machine. The proposed machine is to have a capacity of 11,000,000 lbs. in tension and 10,000,000 lbs. in compression. The bill calls for an expenditure of \$1,750,000. This machine will be much larger than anything else in the world, and will enable the government to make tests of structural members and obtain exact information which will be of great benefit to all who are concerned in the erection and stability of great steel structures.

The Hoskins Mfg. Co., of Chicago, has removed its factory to Detroit, Mich., the new site being on Lawton avenue, adjoining the Michigan Central Railroad, which affords the company excellent shipping facilities. The business of the Hoskins Mfg. Co. includes the manufacture of many forms of hydro-carbon blow-pipes and furnaces, and also new and improved electric furnaces. The operations of the company will now be carried on in a much larger scale.

PLANT OF J. T. BAKER CHEMICAL CO., PHILLIPSBURG, PA.

The plant of the J. T. Baker Chemical Co. is located at Phillipsburg, N. J., on the east side of the Delaware river, opposite Easton, Pa., and adjoins the "Del. Del." Division of the Pennsylvania railroad.

The J. T. Baker Chemical Co. is a stock company with an authorized capital of \$150,000. The directors are: J. T. Baker, President; C. D. Davis, Treasurer; H. H. Garis, Secretary; Wm. P. Fitzgerald, Chief Chemist. The plant was built in 1904 and is a modern plant in every respect, being equipped with the most approved devices for economy and efficiency that years of experience could suggest. It covers three acres of land and includes a dozen buildings constructed of brick or wood, each building being devoted to some special purpose, and separated from each other by sufficient space to prevent contamination by

reduction in prices follows, by reason of competition, the manufacturers in the end are all benefited by an increase in the volume of business done. If one studies the situation carefully he will see that this has been the case in the C. P. Chemical business in the past. Twenty-five years ago there were very few concerns that maintained chemical laboratories, and the majority of these were steel makers, while today there is hardly an industry of any description be it steel, iron, mining, soap, sugar, oils and even farming, that does not employ an analytical chemist in some capacity. Furthermore, there is not a college or even a first class school that does not have a chemical course which not only requires chemicals but is from year to year turning out chemists to create a larger consumption. There is undoubtedly an increase in demand for chemicals as well as for most other products of manufacture, of at least 20 per cent each year.



Plant of J. T. Baker Chemical Co., Phillipsburg, N. J.

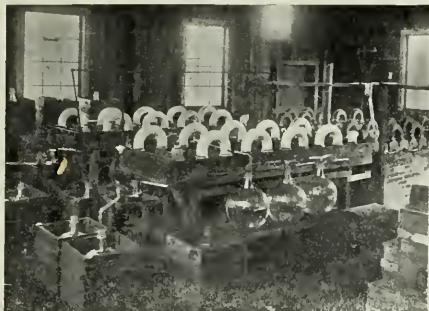
fumes from adjoining buildings, and also to insure as far as possible against spread of fire.

The products of manufacture are high grade chemicals, mainly chemically pure reagents for analytical work in industrial and experimental laboratories. The object in starting a new plant for the manufacture of this line of chemicals was two-fold. The first was to take advantage of the constantly increasing demand for chemicals used in analytical work, for in this line of business as in all others, there has been a steady increase in consumption from year to year. When a new manufacturer enters any field of industry, in which the balance between supply and demand may seem about even, it does not necessarily mean that a division of the business and a ruinous competition in prices will follow, although this may occur to some extent until things assume a normal condition, but it is a strong indication, and one which is generally borne out by experience, of an increase in consumption. Even if a

The second reason for starting a new plant for the manufacture of chemicals of this character, was to meet the demands of chemists for chemical reagents of a greater degree of purity. In order to meet this demand and at the same time to keep down the cost, it was necessary to introduce radical changes in the method of manufacture. Chemical plants like machinery sometimes reach a point where it is more economical to tear down and begin over again than to attempt to reconstruct. In a new plant every detail for effecting economy and improving methods can be worked out to the greatest degree of perfection.

In the J. T. Baker Chemical Co.'s plant nothing that could add to the economy and efficiency of the plant was overlooked. The buildings are all substantial and arranged with a view for saving labor in the handling of material. Separate buildings are devoted exclusively to the manufacture of HCl , HNO_3 , H_2SO_4 , and NH_4HO and one large building is used exclusively for

the preparation of chemical salts. Various smaller buildings for distilling, calcining, etc., together with shipping department, storehouses, office, etc., complete the group of buildings. All the buildings are on a level and tracks running through the plant facilitate the handling of material.



Acid Distilling; J. T. Baker Chemical Co.

A large steam plant furnishes steam heat for the steam baths where the chemical salts are purified by recrystallization, also power for generating electric current for light and power in different parts of the plant. Compressed air is used exclusively for elevating acids and other liquids and a fuel oil system furnishes heat for all the furnaces and stills throughout the plant. The purest water is obtained from a driven



Crystallizing Room; J. T. Baker Chemical Co.

well 200 ft. below the surface of the ground. In the distillation of acids the whole process is automatic. The acid is elevated by compressed air into a tank from which it flows by gravity through the still in a uniform stream, while the distillation goes on continuously and the condensed acid flows by gravity into receivers, pure and ready for shipment without any handling. To obviate breakage, which is unavoidable when using glass for distilling and condensing acids, an apparatus made entirely of porcelain was devised after some months of experimenting for distilling not only HCl and HNO_3 but H_2SO_4 as well. While this has been very costly in the outlay, on account of the

high price of porcelain ware, it has proved very economical in operation and this is the only plant in this country using porcelain exclusively for distilling and condensing acids.

In the preparation of chemical salts porcelain is also used extensively, particularly, large porcelain evaporating dishes, porcelain lined steam jacketed kettles, etc. Centrifugal machines are used for extracting the mother liquor from the crystals, and steam heated air, the temperature of which is regulated by thermostats to suit the conditions, is used for final drying. The air passing into the crystallizing rooms and into the drying rooms is all filtered to remove particles of dust. Machinery for stirring, grinding and pulverizing add to the economy by saving labor and increasing the output.

Chemicals of the highest degree of purity are produced and in addition to labeling them "C. P." in the



Bottling Department; J. T. Baker Chemical Co

usual manner, this company introduced the practical idea of adding to the doubtful significance of the term "C. P." an analysis showing as clearly as possible on each particular label what "C. P." stands for. This innovation has proved a great success and "Baker's Analyzed Chemicals" are rapidly becoming known throughout the country not only for their high degree of purity but as a standard of purity which is reasonable and practical, and one which meets the demands of the chemist.

The plant is always open for inspection by any who may be interested in chemical manufacture and visitors are always welcome.

The Secretary of the Treasury has transmitted to Congress a communication from the Secretary of the Interior, urging the erection of a fireproof building for the Geological Survey and other bureaus of the Department of the Interior. An estimate of \$2,500,000 is also submitted as the probable cost of such a building as is required. The appropriation for this purpose should unquestionably be much larger than the above, as in keeping with the enormous mineral resources of this country.

DENVER WORKS OF THE WESTERN CHEMICAL MANUFACTURING COMPANY.

By R. B. HOSKER.

*Secretary of the Western Chemical Manufacturing Co.,
Denver, Colo.*

The first attempt to manufacture chemicals in Colorado was made by Wm. West in 1875, when a small sulphuric acid plant of 2,000 pounds daily capacity was erected. From that time until 1885, when the Western Chemical Works Co. was organized, the chemical industry in this state was practically nil. The history of the latter company is very interesting, the struggles for success being many and varied, but eventually, by the untiring efforts of E. M. Ashley and his son, F. R. Ashley, together with John C. Skinner (who took charge of the plant in 1892), the concern has become one of Denver's most successful industries.

The present company, the Western Chemical Manufacturing Co., was the result of a reorganization in 1902. The officers are F. R. Ashley, president and general manager; C. B. Kountze, vice president; J. C. Skinner, treasurer and general superintendent; R. B. Hosker, secretary.

The works are situated about three miles from the Denver postoffice and are spread over an area of about 35 acres, while over 20 acres of land belonging to the company are available for future developments. The products at present manufactured embrace the following: Commercial sulphuric, muriatic and nitric acids, aqua and anhydrous ammonia, chemically pure acids and ammonia, liquid carbonic acid gas, copperas, etc.

The sulphuric acid department consists of four distinct plants, arranged so that each can be operated separately. The combined plants are operated by 16 Herreshoff furnaces, which are connected with 13 lead chambers, 4 Glover and 4 Gay-Lussac towers. The chambers are of 6-pound lead, 110 feet long, 25 feet high and 30 feet wide. The producing capacity of the four plants is approximately 3,000,000 pounds of sulphuric acid monthly. The entire plant when in operation has a capacity fully 50 per cent in excess of the western demand. There are two plants each for the manufacture of muriatic and nitric acid.

The chemically pure acid and ammonia departments are strictly up to date, there being a separate building for each kind. The greatest care is taken to insure the preparation of goods of absolute purity, and both the acids and ammonia are manufactured entirely in glass vessels, and all the products are carefully examined by a competent chemist prior to being bottled.

The chemically pure goods are now being used by practically all the smelters west of the Missouri river, also by all the leading chemists and assayers in the western country. This alone is a sufficient guarantee of the purity of these goods. This department is in charge of Geo. C. Piwonka.

All ammonia, whether in the form of aqua, anhydrous, carbonate, chloride or sulphate of ammonia, is obtained primarily from one and the same source, viz., gas liquor, which is merely water that has been applied to the washing of coal gas, whether such washing be done by gas companies supplying illuminating gas or by by-product coke oven companies, whose business is mainly the manufacture of coke. This gas liquor, or wash water, as it may be called, contains ammonia along with many other substances of little or no value at the present time. The ammonia is usually present in ordinary gas liquor to the extent of say from 1% to 1.5% in the condition principally of carbonate of ammonia, along with some sulphide and other combinations of sulphur and ammonia. This so-called gas liquor is today the source of all commercial ammonia.

In the manufacture of aqua and anhydrous ammonia this gas liquor is subjected to a process of distillation, or, more properly speaking, a series of distillations, by which the ammonia is freed from the gas liquor. Before, however, the liquor is distilled, or during such distillation, the liquor is treated with caustic lime for the purpose of decomposing the ammoniacal salts contained in the gas liquor, and thus setting free the ammonia in a gaseous condition.



View of Western Chemical Mfg. Co.'s Works in 1891.

The apparatus in which this distillation is conducted consists of large cylindrical vessels made of strong boiler plate and capable of withstanding considerable pressure. In these vessels the gas liquor is subject to distillation; while at the same time it is brought into intimate contact with the lime, before mentioned, by means of stirrers, or agitating gear. In this manner is effected the decomposition of the ammonia compounds of the gas liquor and the expulsion of the liberated ammonia gas therefrom.

The ammonia gas so evolved is, however, accompanied by various volatile substances which must be removed before the ammonia can be made a marketable article. Suffice it to say that to those familiar with the business, this offers no insuperable difficulty. The company has installed a unique device by which all the impurities are entirely eliminated. The am-

monia gas, after having been purified, is now in condition suitable for conversion into either aqua or anhydrous ammonia; the former is what is used in the drug and paint business and in the manufacture of ice in the so-called absorption machine, and by subsequent further dilution with water in the preparation of household ammonia. Aqua ammonia, as put on the market by the manufacturer, contains 70% of water and 30% of ammonia gas, by weight, and has a specific gravity of 26° Beaume. Anhydrous ammonia, on the other hand, contains no water, but is simply the purified ammonia gas liquefied by means of the combined influence of great pressure and fairly low temperature.

The choice of converting the ammonia gas into aqua ammonia or hydrous ammonia, of course rests with the manufacturer, and in this matter, as in others, the condition of the market is the controlling factor. If it is found to be more profitable to make aqua than anhydrous ammonia, then the ammonia gas is simply led

To further purify this liquid anhydrous ammonia, it is subjected to re-distillations, the impurities being retained as residues to be otherwise disposed of.

This scheme of repeated distillations, while very effective, may, if found necessary, be supplemented by filtration through various alkaline substances, such as through caustic potash, or caustic soda, or even newly burnt lime, these having the tendency to remove moisture, i. e., if such be present in the liquified ammonia gas.

The finished product must be perfectly pure and dry, leaving no residue upon evaporation. Great care, however, is required in the taking of samples for testing purposes, to insure against the introductions of moisture from the surrounding air, as anhydrous ammonia is hygroscopic to a high degree.

The liquified anhydrous ammonia is forced into steel cylinders of 50-lb. and 150-lb. capacities, and is ready for the market.



View of Present Works of Western Chemical Mfg. Co.

from the purifiers and made to pass into distilled water, wherein it is rapidly dissolved. In the act of absorption, however, considerable heat is evolved, and this must be removed as fast as formed, otherwise this increase would seriously, if not altogether, interfere with the further absorption of the ammonia gas. When the water has absorbed about 30% by weight of ammonia gas, it is called aqua ammonia, 25° Beaume, and is put on the market as such.

If the manufacturer finds it more profitable to make anhydrous than aqua ammonia, the ammonia gas leaving the stills, or generators, after being submitted to the same scheme of purification as that intended for the manufacture of aqua, can be drawn away by powerful gas compressors, or pumps, and submitted to a pressure of from 150 lbs. to 180 lbs. per square in., while at the same time it is deprived of its heat of compression by being made to pass through cooling coils and thus liquified.

The liquified ammonia thus obtained, however, is far from being pure and must in consequence undergo further purification before it will be acceptable to the consumer. Perhaps there is no commercial chemical substance on the market today that is required to be so pure and free from all foreign impurities as is anhydrous ammonia.

In the manufacture of ammonia a large amount of burnt lime is daily required for the purposes heretofore set forth. In order to obtain this it has been found necessary to build a kiln and make lime on the premises and thus secure the full benefit of freshly prepared material, lime-rock, or limestone, as it is called, being used for this purpose. Lime-rock consists of calcium oxide and carbonic acid gas, the latter to the extent of about 44%, and it is with the object of expelling this carbonic acid gas that the limestone is placed in the kiln and heated. To waste such a large amount of carbonic acid would be obviously wrong; therefore, the company has erected a carbonic acid works and is turning out regularly a large amount of this material in liquified form.

In order to do this, the gases leaving the lime kiln, which, by the way, are a mixture of air, nitrogen, and carbonic acid gases, are drawn from the top of the kiln by means of a powerful fan, and made, after repeated purifications, to pass up through towers and encounter a descending solution of lye. The lye has the property of absorbing the carbonic acid in the mixed gases and retaining it, allowing, however, the other gases, air and nitrogen to escape.

All that is necessary to recover the absorbed carbonic acid from the lye is to subject the lye to heat in

boilers. When the carbonic acid is driven off, the lye, after cooling, is again used for the absorption of a further quantity of carbonic acid in the above-mentioned towers.

The carbonic acid, after leaving the boilers, passes into a gas holder, from whence it is passed through calcium chloride to remove any moisture, and is then led to a very powerful compressor of the 4-stage type, wherein it is liquified, at a pressure of about 1,200 lbs. per sq. in.

The liquified gas is then stored in strong cylinders, in quantities of 18, 20, 25 and 50 lbs., and is ready for the market. These cylinders, we may say, have been tested to a pressure of 3,700 lbs. per sq. in. and are, in consequence, perfectly safe at the pressure above mentioned.

The ammonia and carbonic acid plants were erected under the supervision of Thos. Charlton, who has had considerable experience with the manufacture of these products.

In consequence of the decreasing demand for sulphuric acid the company decided to erect a mill and engage in the zinc milling industry and at the same time produce an ore suitable for roasting in the Herreshoff furnaces and subsequently, to separate the zinc and lead contents as by-products. This mill is now in operation. The installation comprises the following departments: Sampling, or coarse crushing mill, dryers, fine crushing mill, roasters, magnetic separating mill and wet concentrating mill.

The sampling mill consists of picking belt, one 10"x20" Blake crusher, one set 16"x36" McFarlane rolls, trommel, double Vezin sampler, elevators and conveyors. There are two dryers, one White-Howell revolving drum, the other a Holthoff-Wetthey rabble roaster. In the fine-crushing mill are two sets 16"x36" McFarlane rolls, one Rowand type Edison screen, one Perfection dust collector, elevators and conveyors.

The magnetic separating mill contains one Cleveland-Knowles 21", and one type "E," two-pole, Wetherill separator, one Rowand type Edison screen, one Perfection dust collector, two small Vezin samplers, elevators and conveyors. At present but six concentrating tables are being used, but floor space has been provided for ten.

In operation the ore is shoveled from the cars to the picking belt which feeds a shaking grizzly. The overs of the grizzly go through the crusher and, after joining the throughs, are carried by belt conveyor to an elevator and discharged into the trommel. The overs of the trommel go to the rolls and are returned by the same elevator to the trommel. The throughs of the trommel are carried by elevator to the double Vezin sampler, which works in tandem and cuts out about 1% for a sample.

After passing the sample the coarse-crushed ore goes by belt conveyors direct to dryers, or to hopper in bedding floor building, from which it is drawn into a tram car and dumped at any point upon the floor. This

floor is about 75 ft. x 112 ft., and will hold approximately 3,000 tons of sulphide ore.

From the bedding floor the ore is trammed as needed in push carts holding 1,000 lbs. and dumped into an elevator pit and is carried by the elevator and belt conveyor to either of the two dryers.

The dry ore is conveyed by an oscillating conveyor to an elevator, which feeds the screen in fine-crushing mill. This screen has two sizes of perforations. The overs go to the medium roll; the throughs of the coarse perforations go to the fine rolls. Both rolls deliver back to the elevator which feeds the screen. The throughs of the fine section of the screen go by belt conveyor to one of three bins. These bins are arranged to serve the wet mill, the raw magnetic mill, or the roasting furnaces.

At present the ore is carried from the bins on an incline belt conveyor and discharged into a hopper over the roasting furnaces, from whence it is drawn into a tram car, weighed and dumped into roaster hoppers.

The roasted ore is returned to the separating mill, where it is sized on the Rowand screen and delivered to the separators.

The magnetic iron and zinc are carried on belt conveyors to automatic samplers and delivered by elevators, the former to shipping bins and the latter to Wilfley tables.

The tables make three products—lead, zinc and silica. The lead and zinc are delivered into burlap-lined bins by Frenier sand pumps and the silica is washed into the dump.

All the different sections of the mill have separate motor drivers except the wet mill, which at present is driven from the magnetic mill motor.

The mill has a present capacity of 50 tons, but is capable of being enlarged at small cost to 100-125 tons per day.

All kinds of milling zinc ores are to be treated, including middling products and low-grade zinc concentrates from other mills.

The mill, which is practically automatic, was designed by R. M. Henderson (who also has charge of the milling operations).

A power plant is being erected which will consist of three 200 h. p. gas producers installed by the Westinghouse Machine Company, Pittsburg, Pa., and two Westinghouse gas engines, one 190 h. p. and the other 160 h. p. It is the intention to produce power, light and fuel gas for the entire plant. Lewis B. Skinner, the consulting chemist and metallurgist of the company, has supervision of this work.

Nearly 2,000,000 h. p. in the form of gas is allowed to escape from the blast furnaces of the country. This condition is rapidly being changed by the installation of gas engines to develop the power. There is also a great fuel waste in the manufacture of coke, besides the loss of many valuable by-products. It is estimated that these losses amount to \$50,000,000 annually.

THE COMMERCIAL MANUFACTURE OF AMORPHOUS CALCIUM PHOSPHIDE.¹

By CHARLES E. MUNROE.

Professor of Chemistry, The George Washington University, Washington, D. C.

In 1891, I was directed to prepare calcium phosphide on a limited commercial scale. The Howell Automobile Torpedo had then been developed to such an extent that it had been tentatively accepted as a service weapon, and officers and seamen gunners of the navy were being trained, by target practice, to become skilled in its use. As devised, this torpedo was so constructed that, as ready for service, it would, when stationary or running at low speed, fill with water to such an extent as to sink the torpedo and drown its priming charge and detonator so as to render them harmless, for, if in action a live torpedo failed to hit the enemy at which it was aimed and became a vagrant, it would prove a menace to friend as well as foe. Although, in target practice, the war heads were not used it was necessary that otherwise the torpedo should be arranged and should operate as in action. But the sinking of the torpedoes at the end of their runs was, owing to the difficulty of locating them in deep water, a serious impediment to practice, as they were expensive. Hence, it was most desirable to recover them. Various devices were invented with the object of surmounting this difficulty. The one which proved most efficient was the inserting in the nose of the torpedo of a can of calcium phosphide, with holes punctured in the top of the can, for as the torpedo took the water the reaction of the phosphide with the water entering the can gave rise to a cloud of smoke, which was visible by day, and a faintly luminous flame, which was visible by night, and these phenomena enabled one not only to easily follow the course of the torpedo during its run but also to locate it with great accuracy after it had sunk. It thus became easily possible to recover the torpedo by grappling.

As there was previous to the erection of this furnace, no manufacture, so far as was known, of calcium phosphide in this country, it was imported from Europe at a cost of \$2.25 per pound. Quite apart from the high cost a difficulty was met in importing it, owing to the custom's officers, who insisted on breaking open the sealed packages and inspecting their contents greatly to the disgust of both the inspecting officers and the importers, though for different reasons, and to the damage of the material. For these various reasons, I was directed to manufacture it and the material was then supplied by the government to the company furnishing the torpedoes.

From the literature it was learned that Dumas² placed fragments of quicklime in a retort set horizontally on a grate and disposed phosphorus at the extremity of the neck, which was closed with a stopper. When the lime had been heated to redness

the phosphorus was passed over it in the state of a vapor, thus producing calcium phosphide.

Thenard³ made use of a clay crucible, of about 1 liter capacity pierced at the bottom by a hole 1 to 2 cm. in diameter. The neck of a glass flask, of about 250 cc. capacity was passed through the hole in the bottom of the crucible and luted in place, and the whole arranged in a furnace with a double grate, so that the flask hung suspended above the lower grate. The flask was filled with phosphorus and the crucible above it with quicklime. When the lime had been heated to redness, heat was applied to the glass flask and thus the vapors of the phosphorus were passed through and about the lime. The operation lasted 30 to 40 minutes and about 500 to 600 grams of the phosphide were obtained.

A preferred form of crucible recommended by Thenard, was one which was divided into two parts by an earthenware grid, the lower section, about $\frac{1}{3}$ to $\frac{1}{4}$ the height of the crucible, being used to hold the phosphorus. Such a crucible is pictured by Pelouze et Fremy⁴, but they effected the division by placing a small crucible inside the large one and placing the grid on the small one. However, they continued the use of a furnace with two grates.

Gattermann and Haussknecht⁵ made use of a covered Hessian crucible, resting on the grate of a crucible furnace, in which to put the lime, and when the latter had been brought to a glow, they dropped in sticks of phosphorus by means of a vertical iron tube which passed through the covers of the furnace and crucible, and reached to within 2 cm. of the bottom of the crucible, the upper end of the iron tube having a glass tube fitted into it by means of an asbestos packing.⁶ They used about 500 grams of lime and added to it 350 to 400 grams of phosphorus.

This was the state of the art as I found it at the time of beginning the work. Experiments were made with glass and earthenware vessels, but they proved unsatisfactory. Tests were then made with an iron tube, butt welded at one end, and this resisted the action of molten and vaporized phosphorus so well that crucibles were made from 5-inch wrought iron tubes with welded bottoms, their dimensions being as follows: depth inside 6 inches, outside 7 inches, diameter at top, inside 5 inches, outside 5 $\frac{5}{7}$ inches. They were provided with grooved lids, $\frac{1}{4}$ -inch thick and 6 inches outside diameter, which were fitted with asbestos gaskets. A slotted lug was welded on each side of each crucible and a wedge shaped iron key was provided so that by driving it through the slots the cover of a crucible was easily fastened on tightly and firmly. Through one side of the cover a wrought iron pipe, 12 inches long, and 1 inch in diameter, was swaged, the lower end of the pipe being flush with the inside face

² Ann. Chim. Phys. (4) 14, 12; 1845.

³ Traité de chimie 2, 558; 1865.

⁴ Beriché, page 1175; 1890.

⁵ This apparatus, except for the glass extension tube, is practically identical with that of Mr. Silas shown in Mémoires militaires et scientifiques 5, (XXXII) 9, 1877.

¹ Ann. Chim. Phys. (2) 23, 363; 1826.

of the crucible cover. This pipe was provided with a cap 4 inches long and $1\frac{1}{4}$ inches inside diameter. These pots held about 1,500 grams of lime each. They were heated with coal in an ordinary square crucible furnace.

The lime used was "black marble lime, wood burned." It was of high quality and it was broken into lumps 1 to $1\frac{1}{2}$ inches in diameter. The crucible was charged with the lime, the cover put on and keyed, and the whole lifted by the feed pipe and bedded in the fire in the furnace. When the crucible had become heated to between a dark and cherry redness the cap was lifted from the feed pipe, sticks of dry phosphorus were dropped in and the cap replaced. So soon as fuming ceased, which with the right proportion of phosphorus was almost immediately, the crucible was lifted from the furnace and allowed to cool with the cap on so as to prevent air from reaching the phosphide in any considerable volume during the cooling process. The operation required about $\frac{1}{2}$ hour. With 1,400 grams of lime to the pot and 200 grams of phosphorus added about 1,600 grams of phosphide was obtained. With a larger quantity of phosphorus the yield was no greater as the excess of phosphorus fumed off. Using four pots, an unskilled workman, after short practice, turned out 28 pounds per short day. The cost, counting labor and materials, was 20 cents per pound. The same pots were used, without repairs, for some eight years.

The phosphide produced in this way was very active giving off spontaneously inflammable hydrogen phosphide promptly on contact with water. A perforated tin container holding a pound of this amorphous calcium phosphide, when submerged in 18 feet of sea water, gave a flame, which rose some two feet above the surface of the water, and voluminous smoke, and it continued intermittently to give off flame and smoke for over five hours. It was found to be more satisfactory in its behavior than the imported article. Portions of it made 17 years ago seem to-day to be as active as when freshly manufactured.

Since this work was accomplished, H. Moissan⁶ has obtained calcium phosphide by reducing tricalcium phosphate with carbon in an electric furnace, and also by the action of phosphorus on metallic calcium. The product thus obtained was crystalline and it reacted with water to produce phosphine (H_3P), which was not spontaneously inflammable, while the product obtained by the action of phosphorus on lime, after the manner described above, is amorphous and reacts with water to produce hydraphosphine (H_4P_2), to which is attributed its property of generating a spontaneously inflammable product. E. Renault⁷ has also obtained the crystalline calcium phosphide in the electric furnace, carrying out the operation in both iron and carbon crucibles, but he states that under certain circumstances he obtained, from the tricalcium phos-

phate, a phosphide which yielded both H_3P and H_4P_2 . This is quite to be expected, for I recall that when operating the plant at Spray, N. C., in 1895, for the production of calcium carbide, I noted the presence of calcium phosphide in the product, due to reduction of calcium phosphate in the lime, and I attributed the spontaneous inflammation of the acetylene, and other gases, produced by the reaction of the carbide with water, to the simultaneous formation of hydraphosphine.

No doubt if there was any considerable demand for amorphous calcium phosphide it could be most economically met by electric furnace methods, but as the uses for this material are limited the method I have described is sufficient and commends itself for its simplicity, low cost of installation, the wide accessibility of the apparatus and materials used, and the ease with which it can be carried out by unskilled labor.

With this manufacture in successful operation in the navy there was naturally a desire to further utilize the product in the solution of other naval problems. It had then been recognized that the electric search lights installed in the navy were not an unmixed blessing, for while they might be used in locating the enemy they never failed also when in use to locate the vessel that carried them, and therefore they failed in enabling one to take the enemy by surprise. It was evident that this defect could be remedied by means of a self-igniting light which could be thrown, say in a shell from a gun, among the enemy. With this in view, experiments were made with the product from this furnace, but though perfectly clear, yet quite dark, nights were chosen for the tests, when the vessels in the harbor were at anchor with some of their sails spread, and the seamen gunners who laid the test shells were clad in white duck working suits, yet the intrinsic luminosity of the phosphide flame was so slight that no useful result was obtained. Quite recently, however, according to reports, this result has been successfully accomplished, and we find in calcium carbide, mixed with calcium phosphide, a material which, when thrown to a distance, will, when alighting in water, produce a self-igniting flame which has a high intrinsic illuminating power.

But the economic use to which this material has been longest put, and even to-day, probably, the chief use to which it is put, is as an attachment to life-saving emergency buoys which are carried aboard passenger vessels in locations from which they may be readily thrown at the call of "Man Overboard," for though the flame given by the phosphide is dim, yet it is often sufficient to enable the person struggling in the water to locate the buoy. This application is described in great detail in *De l'application de phosphure de calcium a l'appareil éclairant des bouées de sauvetage*,⁸ and it therefore will not be enlarged upon here.

⁶ Comptes rendus 128, 883-884; 1898.

⁷ Mémoires militaires et scientifiques 1878, xxxii.

⁸ Comptes rendus 128, 787; 1898.

THE CHEMICAL PLANT

APPARATUS FOR WEIGHING AND MEASURING SOLIDS, LIQUIDS AND GASES.*

Written for THE CHEMICAL ENGINEER.

The problem of weighing and measuring the raw materials employed in chemical and metallurgical processes, as well as the products obtained, is one of the most important which the chemical engineer has to consider. It is, of course, necessary in a great many industries to accurately weigh the reagents which go into the furnaces, retorts and mixing apparatus. It is also at all times desirable to know exactly what the output of the plant is, in order that accurate account may be kept of the cost of manufacture. It is also equally important to correctly check up the quantity of raw materials purchased, in order to guard against fraud or carelessness on the part of the seller.

In accurate work solids are always weighed and liquids and gases are usually measured. Sometimes liquids are weighed and less often solids are measured, the weight of the latter being calculated from

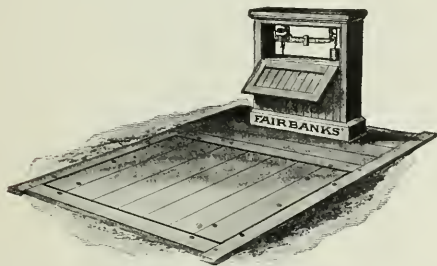


Fig. 1—Platform Scales, The Fairbanks Co.

the weight per unit volume and the known volume. Owing to the fact that solids vary in weight per cubic foot with their fineness, the moisture which they contain, the method employed and the height through which they are dropped into the measure, etc., measurement is not ordinarily a very accurate way of ascertaining the quantity of a solid. For such granular substances as sand and grain, however, it can be used with considerable accuracy.

SOLIDS.

Chemists generally are well enough acquainted with the common forms of scales, and it is hardly worth while here to do much more than to mention some of the less known forms. For weighing barrels, trucks, carts, etc., platform scales are used. The simplest form of these is shown in Fig. 1. This consists

of a platform sunk level with the floor to permit the easy rolling upon it of substances to be weighed. The platform rests upon a system of levers, in a pit, which connect with a beam, on which beam slides a poise, and to the end of which weights are hung. The weighing is all done upon this beam, the heavier weight by means of weights and the final adjustment being made with the poise. These scales may be obtained with single or double beams, in capacities ranging from two to ten tons, having platforms from $6\frac{1}{2} \times 3$ to $8 \times 4\frac{1}{2}$ feet, and costing from \$75 to \$200 according to capacity. Where it is desired to weigh small cars on these scales, rails are laid upon the floor. For weighing railroad cars, however, larger scales having capacities up to 100 tons may be obtained and with platforms up to 80 feet in length. Scales for weighing broad gauge coal cars, etc., should have a capacity of at least 80 tons, and platform 60 ft.

The graduation on the scale-beam will depend upon the size scale, its accuracy, etc.; for instance, a 10-ton scale will usually have the beam graduated to 500 pounds by 2 pounds. Where it is desired to avoid loose weights, a double beam scale may be obtained, the upper bar of which is graduated so as to have a range the entire capacity of the scale. This upper bar is used for the heavier weight and the lower bar for the smaller. The poise on the upper beam is held in its exact position by means of a clamp and notches in the beam. The arrangement usually adds about \$15 to

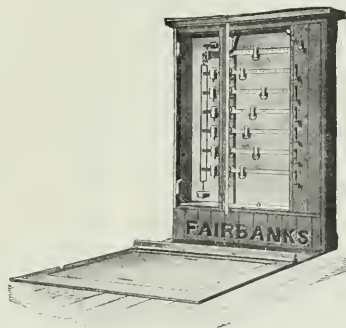


Fig. 2—Furnace Charging Scales, The Fairbanks Co.

\$20 to the cost of the scales. Double beam scales are also obtainable, in which both bars are graduated, one bar being used for the tare of the empty car and the other for the weight. Type registering beams which print the record of the weight upon a card may also be obtained. They add about \$75 to the cost of the scale.

For furnace charging, scales are obtainable having several beams, each of which is employed for weigh-

*This is the fourth series of articles upon the Elements of Chemical Engineering. Former articles treated of the Materials of Construction, Storage of Materials and Conveying Materials. The next series will be upon Preparing Material for Chemical Processes (crushing, pulverizing, etc.).

ing a different component of the charge (see Fig. 2). These scales are fixed so that the beams may be locked in a box and only the pointers appear. By this means the proportions of the charge may be kept secret from the workmen and the weight can not be changed or tampered with. In some of these scales beams are employed which have no graduations or figures upon them. The poise of these is set by the use of a special measure or templet which is placed alongside of the beam when the scale is set. With any of these charging scales, the tare beam is first set to balance the weight of an empty car, and a charging beam is as-



Fig. 3—Hopper Scales, The Fairbanks Co.

signed by number to the weighing of each material. The superintendent or chemist sets the poise on each beam to the number of pounds of the material (to which this beam is assigned) which is wanted in each charge. The beam box is then locked. As each material, in order, is placed upon the borrow, the operator turns the key of the beam assigned to that material and adds to or takes from his load until the scales balance.

The poise is locked at the proper place on the beam by a very simple device. The under side of the beam is notched and the loop in the poise has notched ends to fit into the notches on the beam. When the loop is up the notches are disengaged and the poise can be slipped along the beams. When the loop is down the notches catch and the poise can not move accidentally.

Another form of scale which is sometimes used in furnace charging consists of a car, somewhat similar to a coke oven larry, which is mounted upon a scale on trucks. The car can be run along under different bins of material, the proper quantity of each added, and the whole charge then run to the furnace and dumped.

For weighing large quantities of loose material, hopper scales are often employed, such as are shown in Fig. 3. These consist simply of a scale in which a

large hopper or bin takes the place of a platform. The hopper may be made of wood or sheet metal, and its bottom is provided with a slide; the material is run in and weighed, when the slide is drawn and the hopper discharged. These scales often give a very simple way of checking the product of or the supplies purchased by an industrial plant. For instance, the material is run into the scale hopper from another hopper above, which is filled in turn by a conveyor. The scale hopper is then weighed and dumped into a bin or onto another conveyor and passed on to storage or the process. The disadvantage of this arrangement is, of

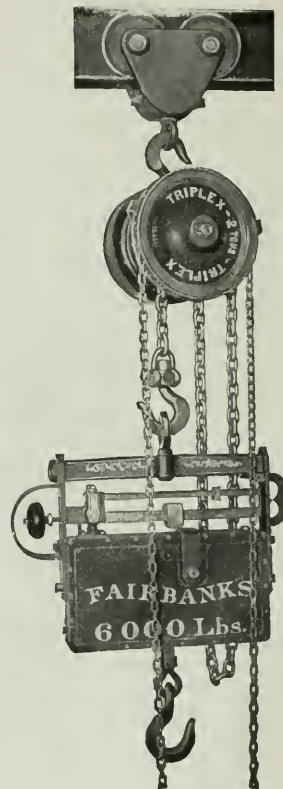


Fig. 4—Compound Suspension Scales on Yale & Towne Chain Hoist, The Fairbanks Co.

course, the fact that constant attendance is necessary.

A simple form of scale which is very useful in metallurgical plants where billets, ingots, castings, etc., are weighed, or in chemical plants for weighing casks, carboys, and drums, in the act of being loaded or unloaded, is the compound suspension scale. This may be obtained with capacities up to 40,000 pounds and to cost from \$50 to \$400. Fig. 4 shows such a scale suspended from a Yale and Towne triplex chain hoist. With this a cask or other substance to be weighed can be lifted directly from the floor, weighed and rolled along the overhead track to the point of

use or storage, where it can be lowered again; all by means of the chain hoist.

All the scales mentioned above require attendance. Of late, a number of automatic weighing devices have been brought forward. Some of these appliances are

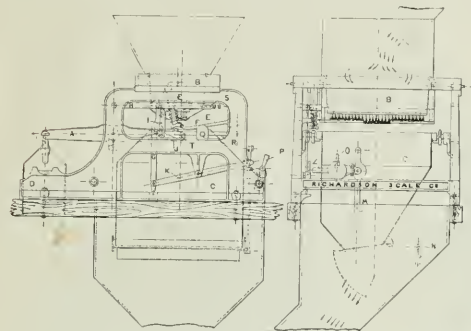


Fig. 5—Richardson Automatic Scale (View), Richardson Scale Co.

Fig. 6—Richardson Automatic Scale (Details), Richardson Scale Co.

very satisfactory, others naturally are not so good and some are usually "out of order." One of the best known forms of automatic scales is the "Richardson Automatic Scale," manufactured by the Richardson Scale Co. This is shown in Figs. 5 and 6.

The scale has an equal armed beam, *A*, which is supported at the center on knife edges resting on bearings on the frame of the machine. Suspended on one end of this is a hopper, *C*, made to any required capacity, in which the material is weighed, and to the other the weight box, *D*, is hung, in which ordinary dead weights are placed for the required load.

The empty hopper, *C*, and the empty box, *D*, are arranged so as to exactly balance each other, the beam being in a horizontal position, perfectly balanced. The supply of material, delivered by way of the chute, *B*, is regulated by the swinging gate, *E*. Weights for the required amount are placed in the box, *D*, when that end of the beam is depressed so that the opposite end is elevated and opens the supply gate, *E*, through the pendant spring, *F*. The material is now delivered to the weighing hopper, *C*, and this continues unarrested until the charge is nearly complete. The weight of the material, together with the weight of the supply gate, *E*, acting through the pendant, *F*, now depresses the weighing hopper, *C*, and this continues unarrested until the charge is nearly complete. The weight of the material, together with the weight of the supply gate, *E*, acting through the pendant, *F*, now depresses the weighing hopper, *C*, and this continues unarrested until the charge is nearly complete. The weight of the material, together with the weight of the supply gate, *E*, acting through the pendant, *F*, now depresses the weighing hopper, *C*, and this continues unarrested until the charge is nearly complete. The weight of the material, together with the weight of the supply gate, *E*, acting through the pendant, *F*, now depresses the weighing hopper, *C*, and this continues unarrested until the charge is nearly complete.

The beam, *A*, is now released of the weight of the gate, *E*, and the supply is partially cut off. The remaining stream continues until the hopper receives the precise amount, whereupon the beam coming to its balance knocks aside the arm, *J*, of the trigger, *I*, and permits the bar, *G*, to fall. The gate, *E*, is now closed and the free end of the lever, *K*, engages with the

bolt, *L*, throwing the toggle, *M*, out of the perpendicular, thereby allowing the weight of the material in the hopper, *C*, to open the door and discharge. The weighted end of the beam now declines and would force the gate, *E*, open were it not locked by the toggles, *H* and *G*, forming a dead center. The hopper door returns by means of the balance weight, *N*. The illustration shows the scale in a position preparatory to its discharge, with the supply gate closed. The rebound of the machine after its discharge is taken up by a specially prepared steel coil spring, whilst the scale is also provided with special rubber springs which prevent vibration. The return action of the bolt, *L*, on the lever, *K*, has the effect of raising the bar, *G*, which breaks the center formed by *H* and *G* and allows the compression of the spring in the pendant to open the gate, *E*, whereupon a fresh weighing is commenced. The pin in spring, *O*, holds the bar, *L*, in

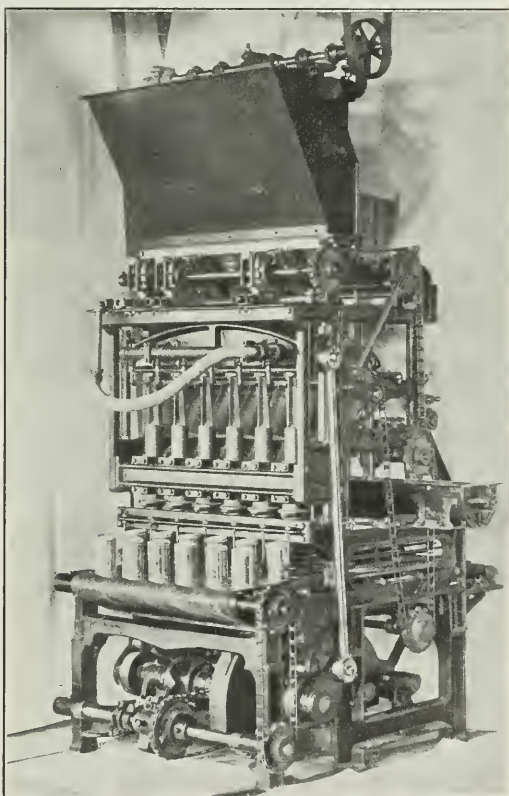


Fig. 7—Baking Powder Weighing and Packing Machine, Automatic Weighing Machine Co.

position. By it the bar can also be turned in allowing the scale to weigh but not discharge. The catch, *P*, is also used to prevent the machine from discharging at any time when it may not be convenient, or to ascertain if the machine is in perfect adjustment. Each

scale is fitted with a dust-proof mechanical counter which registers every weighing automatically. The volume of material falling at the closing of the gate is weighed, or compensated for, by the sliding weight, Q , on the lever, R , acting upon the beam. This is adjustable according to the column falling and causes the beam to cut off the supply when a quantity has been passed which equals the prearranged load, less

be placed side by side and so arranged that they will dump simultaneously into the same conveyor. Such installations have been used successfully, in the manufacture of Portland cement, for automatically mixing shale and limestone in the proper proportions and also for adding gypsum to Portland cement clinker.

Another form of automatic scale which has found considerable use in this country is the "Clark Auto-

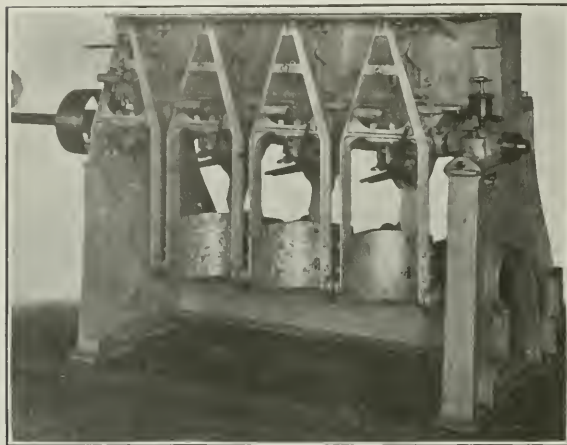


Fig. 8—Bates Automatic Bagging Machine, Bates Valve-Bag Co.

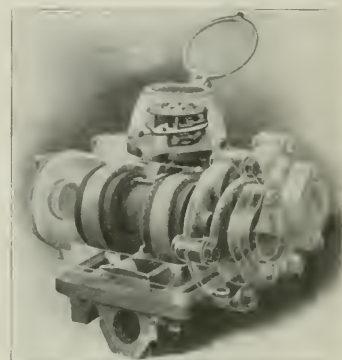


Fig. 10—Piston Meter, Henry R. Worthington.

the weight of material in the process of descending. It will thus be seen that the final flow is not overweight, but just completes the charge, enabling the scale to exactly balance as before shown. By the screw, S , the size and volume of the final dribble is regulated.

Until the material leaves the lip of the discharge door the scale is at a standstill. It is thus impossible for the lower hopper to overflow by the continuous

matic Scale." A number of devices for automatic weighing and packing have been devised. These scales are very ingenious pieces of machinery and are made in a great many forms. The Automatic Weighing Machine Company manufactures a large number of these machines. Fig. 7 shows one of them which is used for packing baking powder. They are designed according to the use to which they are to be put—for packing cereals into cartons, salt into bags, etc.

The "Bates Automatic Bagging Machine" is shown in Fig. 8. This is used extensively for packing cement, salt, hydrated lime and such substances. It depends largely upon a peculiar form of bag known as the "Bates Valve Bag." This consists of a bag having a valve formed by turning down one corner of the bag and sewing parallel with the bottom. The bag is tied before being filled. The thin tube of the bagging machine is thrust into this valve, the material is run in through this, and when the proper weight has been placed in the bag the flow of material is cut off, and the bag withdrawn. When the bag is reversed the weight of the material closes the valve and the package is securely sealed. Paper bags are pasted shut before being filled and are provided with a valve just as are the cloth bags.

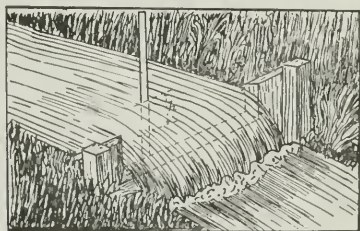


Fig. 9—Wier for Measuring Flow of Water.

discharge of the machine. The scale is modified somewhat for different purposes as experience has indicated, but the main principles are the same in all "Richardson Automatic Scales."

These scales are used extensively for weighing material not only as it comes from cars and belt conveyors, but also for packing purposes in connection with some form of bagging device. Where it is desired to proportion materials, a number of scales may

LIQUIDS.

Liquids may be either measured or weighed, as either can be done with considerable accuracy. The weight can always of course be calculated from the

volume by multiplying the latter by the weight per unit of volume. Or, in other words,

$$W = 62.43 \text{ } \tau d = 8.35 \text{ } l' d.$$

When W = weight in lbs., d = density (water = 1), and τ = volume in cubic feet or l' = volume in gallons.

The weight of liquid in a circular tank will be:

$$W = A^2 \times H \times d \times 49.03.$$

Where A = inside diameter of the tank in feet, H = height in feet and d = density.

Where measurement of running water is to be made, as is often the case when the quantity of the latter flowing through a channel or small stream is desired, this can be accurately done by means of a weir. Such

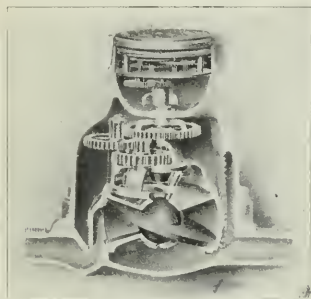


Fig. 11—Disc Meter, Henry P. Worthington.

a weir is shown in Fig. 9. To measure the water with such an appliance, the board is first notched out as shown, the edges are beveled, and, selecting a spot where the water is flowing gently forward, the board is inserted across the stream and mud and turf are placed around it so that all the water must flow through the notch. The surface of the water below the notch should be at least one foot from the lower edge. About three feet behind the notched board a stick should be driven in the bottom of the stream. When the water in the stream has risen level with the lower edge of the notch the stick should be marked at this point. When the latter flows over the notch and has reached its greatest height on the stick, the height of the water above the mark on the stick, level with the lower edge of the notch, should be taken. The quantity of water flowing through can then be calculated from the following formula:

$$Q = 0.4 \times l \times \sqrt{h^3}$$

Q = quantity in cu. ft. per minute.

l = width of notch in inches.

h = depth of water over sill in inches

or

$$G = 2.90 \times l \times \sqrt{h^3}$$

G -- gals. per minute.

h = depth of water over sill in inches.

l = length of notch in inches.

Where it is desired to measure the flow of the water from a large stream a portion of this should be selected its average depth determined, and the length of the

stream measured off. The time which it takes an empty corked bottle to flow this length of the stream should then be determined accurately several times. This, of course, will give the velocity of the stream and from its width and the average depth the quantity of water can be calculated.

For measuring the flow of water through pipes water meters are extensively used. These may be divided into three types. First "displacement meters," in which the water is actually measured by volume, that is to say, a chamber of a given size is filled and emptied several times, and the number of times which it is filled and emptied is indicated by a counter. The second class of meters are known as "current meters." These measure the water by recording the velocity of its flow through a passage of a definite size. This velocity is indicated on a counter or dial. A third class of meters are known as "proportional meters." These measure a definite portion of a stream by passing it through a meter of the first class and thus by measuring a percentage of the total flow, the whole flow is known and recorded on the counter.

The displacement type of meters are the ones most largely used for measuring non-corrosive fluids, such as water, beer, oil, etc. These are of several classes. In one the displacing member is a reciprocating piston, while in another the piston has a continuous or rotary motion. In another the piston has an oscillating motion, and in another class the displacement member is one of nutation. The best known type of displacement meter is probably the Worthington meter shown in Fig. 10. In this there are two cylinders, in each of

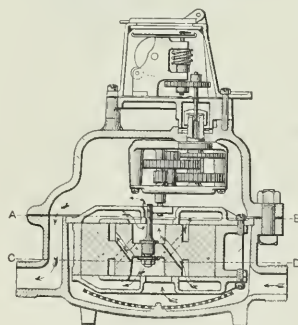


Fig. 12—Rotary Piston Meter, National Meter Co.

which a plunger moves forward and backward carrying a slide valve over ports in the bottom of the meter. Through these ports the chambers at either end of the plungers are alternately placed in communication with the inlet and discharge openings. One of the plungers imparts a reciprocating motion to the lever, shown near the top of the main casing, which in turn operates the counter movement through the spindle and ratchet, as shown. The counter is arranged to move the dial pointers once for every four strokes of the plungers. Water cannot pass through the meter without registration, for all water going through must enter one or

the other cylinder and be displaced by the plungers, and, therefore, recorded by the movement of the lever and counter mechanism; nor can there be an over-registration, because the plungers cannot move without displacing the fluid in the cylinders.

This meter is suitable for measuring a great many liquids such as beer, oil, tan liquor, etc. It may be obtained mounted on a truck so that it may be rolled from one vat to another and used for measuring the contents of these as they are emptied or filled.

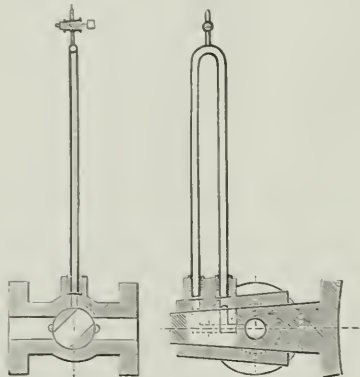


Fig. 13—Rabe Cocks for Measuring Flow of Acids in Pipe Lines.

Fig. 11 shows the Worthington disc meter. In this meter the disc swings around in a chamber and the motion is communicated to the dial by means of clock-work. Fig. 12 shows a rotary piston meter manufactured by the National Meter Co. This consists of a perfectly balanced piston made of hard rubber which moves in a circular manner within a metal cylinder. The motion is controlled by valves and the meter works by displacement. The revolutions of the piston are of course recorded upon a dial, as cubic feet of water.

Water meters usually have their members which come in contact with the fluid covered or lined with tin. They may be used for all liquids which are not too viscous or which do not attack or corrode the interior arrangements or which do not contain solid particles.

For measuring large volumes of water meters of the second and third class mentioned above are employed. The Venturi meter, which belongs to the second class, is very much used for measuring the water used by large industrial concerns. Its principle is similar to that of the Rabe measuring cocks, Fig. 13, which are used for measuring the flow of acids, etc., through pipe lines. These latter have a pointer on the plug of the cock so fixed that it moves along a scale on the body of the appliance. A manometer rises from the body of the cock as shown in the illustration and by means of this the pressure on each side may be accurately determined. The body of liquid flowing through the pipe line will have a higher pressure on the side of the manometer from which the liquid is

flowing, and this difference of pressure is intensified by the plug attached, which separates the two lines of the gage. With the use of this apparatus it is usually necessary to determine the quantity of liquid which the cock will pass when the pointer on the plug and the height of the liquid in the manometer are the same. For instance, if when the indicator on the plug points to five and there is a difference in the manometer of two inches in pressure, 200 gallons of acid will pass through the pipe in an hour, then to duplicate this quantity at any time the operator has only to turn the pointer to 5 and maintain a pressure of 2 inches to obtain exactly the same flow. These cocks are simple and are extensively used on acid lines to indicate the flow of liquid through the pipes.

A box arrangement similar to that shown in Fig. 14 will also give excellent results. The box is usually made of cast iron for corrosive liquids, and for weak sulphuric acid is lead lined. The box is usually about 2 ft. deep and 1½ ft. square. It is divided into two compartments by the partition shown, which runs to

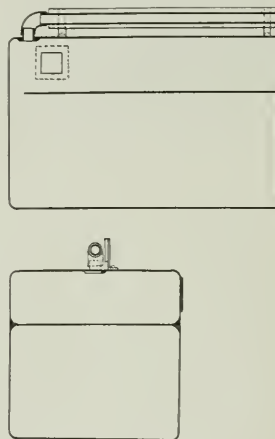


Fig. 14—Measuring Boxes.

within an inch of the bottom. The liquid which it is desired to measure is discharged into the large chamber of the box where it flows under the dividing wall into the outer chamber, and through this latter it finds an exit at an opening made in the side. The size of this latter is determined by the quantity of liquid which it is desired to measure. The best plan is to have an opening in the box some 2 ins. square, and have bolted over this as needed, cast iron or brass plates, pierced with square orifices, 1¼x1¼, 1½x1½ inches, etc., respectively. These openings should be beveled towards the interior of the box with a feathered edge. A glass water gauge is cemented to one side of the box and a scale is placed by the side of this, so as to measure the height to which the fluid rises in the box. The quantity of fluid can then be determined by the height to which the liquid rises in the vessel. The scale must be calibrated for liquids other than

water by actual experiment. The apparatus depends upon the fact that the quantity of liquid which will pass through an orifice in a given time is dependent on the head or height of the level of the liquid above the orifice, hence the quantity of water which is flowing through an orifice at any time will depend upon the height to which the water rises in the gauge. This is a simple method of measuring liquids, but not a very accurate one. The box is merely placed somewhere along the line and the liquid conducted into it by a pipe and the discharge from the orifice carried away by a funnel and pipe.

(To be continued.)

The following are the specifications as to chemical composition of the Pennsylvania railroad system for the steel rails ordered for 1909:

BESSEMER STEEL RAILS.

	Lower Limit.	Desired Composition.	Upper Limit.
Carbon	0.45%	0.50%	0.55%
Manganese	0.80	1.00	1.20
Silicon	0.05	0.12	0.20
Phosphorus	...	...	0.10

OPEN-HEARTH STEEL RAILS—CLASSIFICATION A.

Carbon	0.70%	0.75%	0.83%
Silicon	0.05	0.12	0.20
Manganese	...	...	0.80
Phosphorus	...	...	0.03

OPEN-HEARTH STEEL RAILS—CLASSIFICATION B.

Carbon	0.62%	0.70%	0.75%
Silicon	0.05	0.12	0.20
Manganese	...	...	0.80
Phosphorus	...	...	0.04

We have received from the National Carbon Company, of Cleveland, Ohio, their attractive calendar for 1909. The artistic part of this consists in a hand-tinted platinum photograph of an unusually attractive young woman in evening costume. The calendar part, in addition to the usual matter, contains a lighting schedule showing the time at which the lights should be turned on and off, and also the hours at which the sun and moon rise and set.

A plant for the manufacture of barium chloride from barytes has recently been built by John T. Williams & Son, at Bristol, Tenn., with a capacity of 10 tons of crystals per day. The crude material used in the manufacture of the barium-chloride consists largely of jig tailings, slimes and very iron ore from their barytes plant. The ore is mixed with coal and given a reduction roast in an 80-ft. rotary cement roaster, yielding a mixture of barium sulphide and carbonate. This is leached with hydrochloric acid, which is also manufactured at the plant. The chloride liquor is then filtered, purified by a secret process, evaporated to saturation point and then allowed to crystallize.

AN IMPROVED SULPHUR BURNER.

The large number of uses to which sulphur dioxide is put in the arts renders the great improvement, made in recent years in the methods of producing this gas, a matter of very general interest. This advance has been generally along the lines of largely increased sulphur consumption per square foot of area in the burner, and in the elimination of the difficulties formerly encountered through the production of sulphur trioxide, SO_3 , and the passing over into the gas outlet of a certain amount of sublimed or unconsumed sulphur along with the sulphur dioxide, SO_2 . The sublimed sulphur particularly caused trouble by being deposited in various places as it cooled, and thus clogging up the system.

The Wise agitating burner, Figs. 1 and 2, is the result of much study and experiment as to the best methods of meeting these difficulties. In old style burners the maximum consumption of sulphur is about $2\frac{1}{2}$ lbs. per hour, per square foot of burning area. In the Wise sulphur burner the sulphur consumption runs as high as 16 or even 17 lbs. of sulphur per hour

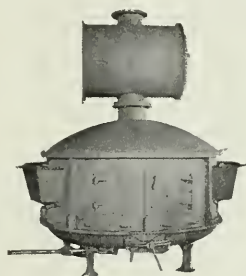


Fig. 1.

per square foot of burning area. This increased capacity, by reducing the number of furnaces, entails great economy in the first cost of any given installation, as well as great saving in floor space, size of building, etc.

The other difficulties in old-style sulphur burners are caused largely by the fluctuating conditions which are inseparable from their use. The sulphur is fed through a door, the cold charge smothering the surface flames, on which it is thrown, for an appreciable period; while the door opened at frequent intervals for feeding purposes, allows an inrush of cold air which cools the furnace, dilutes the gas and causes the production of sulphur trioxide. If the attendant allows the furnace to get a little too hot, through forcing it beyond its capacity or otherwise, or closes the drafts too much after feeding, sublimed sulphur is given off, and a stoppage in the pipes soon results. As the burning sulphur is not stirred or agitated in any way, the unburned residue thrown out from the furnace, generally contains a considerable percentage of unburned sulphur, involving so much absolute loss. To overcome these drawbacks required the introduction of several fundamentally new principles in the

sulphur burner. In the Wise burner the draft slots and dampers once being adjusted remain undisturbed and the air supply remains uniform. The burning sulphur inside is continually agitated, and a high rate of combustion is attained by first practically vaporizing the sulphur and afterwards oxidizing the vapor in a separate chamber.

The general operation of the machine is as follows (see Fig. 2):

In starting, a sufficient quantity of sulphur is thrown in through the front door and ignited in the ordinary way. As soon as this sulphur is melted the agitator is started, and all subsequent charges of sulphur are fed in through the feed hoppers, marked *S B 6* in the accompanying cut, one being located on each side of the burner. The burner once started the front door

gives off partly sulphur dioxide gas and partly vaporized sulphur. The gas and vapor pass up through the neck at the top of the main body of the burner into the auxiliary chamber or combustion box, *S B 12*, where they are brought into contact with fire brick battens of special design, which soon become incandescent, and here the sulphur vapor is entirely consumed, the supply of air for that purpose being admitted at each end of the combustion chamber through the dampers, *S B 21*.

The agitator arm is carried on a shaft extending up through a sleeve in the lower bowl and is driven by a shaft and gears underneath. The whole is driven by a light link chain. As it is unnecessary for the agitator arm to revolve more than four or five times a minute, the power required is practically nothing—not more than $\frac{1}{8}$ h. p.

The efficiency of this machine is naturally very high as no sulphur is lost by sublimation, by being converted into sulphur trioxide or by being thrown out unburned with the residue. The gas from the burner can be made by proper manipulation of the draft slots, to run from 8 or 9% sulphur dioxide up to 16 or 18%.

Some of the industries using sulphur dioxide require the strength of the gas to be at about the lower figure, while others require it to be the strongest gas possible. A high gas test is specially desired in the paper industry.

A large number of these burners are now in use, the first one having been installed in 1905 in the plant of the St. Regis Paper Co., at Deferiet, N. Y.

Press reports from Pittsburg state that the Frick Coke Company has abandoned work, which was to cost over \$3,500,000, on additional coke ovens at Uniontown, Pa., and will substitute for the bee-hive ovens a by-product coke plant at Gary, Ind.

The use of monel metal, in the sheet form, in the roof of the new Pennsylvania railroad station in New York City has directed considerable attention to this new alloy. The monel metal was used, as the result of comparative tests, in preference to copper or other metal. The sheets are laid just as is the case with other metals and are fastened with nails made of monel metal.

Monel metal is an alloy containing 70 per cent nickel and 30 per cent copper, which is smelted directly from the nickel-copper matte produced from ores of the Sudbury district in Canada. The metal is made at the Oxford Copper Company's works at Bayonne, N. J., and is introduced by the International Nickel Co. Monel metal has a high tensile strength, the tests showing much higher results than those given by nickel-steel. It has many good qualities such as resistance to corrosion, taking a fine polish, and possessing in a high degree the qualities of metallic nickel. Among its many applications are for the manufacture of perforated sheets for mining screens, steamship propellers, mine pumps, etc.

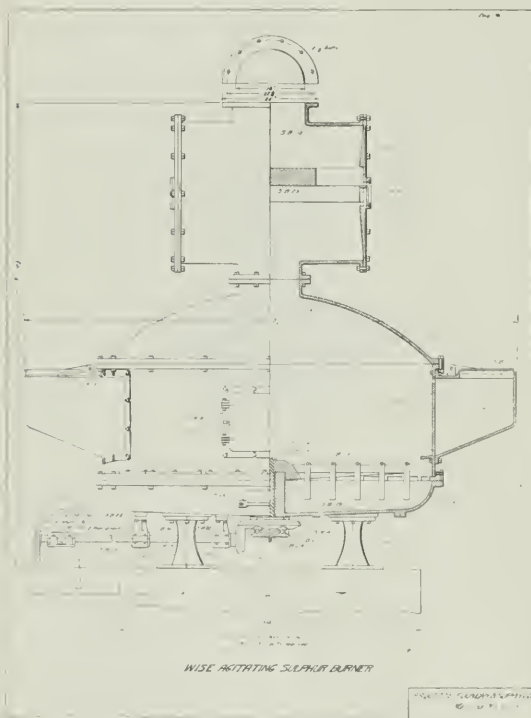


Fig. 2—Sketch Showing General Operation of Wise Agitating Sulphur Burner.

remains continuously closed, thus preventing any inrush of cold air. The sulphur after being thrown into the feed hopper is melted by the heat radiated from the burning sulphur inside and flows into the interior through holes provided for that purpose. Sufficient air to carry on the combustion is admitted through dampers, *S B 27*, arranged around the outer edge of the lower bowl, and these dampers once adjusted are left in position indefinitely, thus giving an entirely uniform air supply. The sulphur inside the burner being agitated and consumed with great rapidity.

AN IMPROVED CONDENSED BATTERY FOR NITRIC ACID.

According to the statistics of the last census 108,380,387 pounds of nitric acid, valued at \$5,232,527, were manufactured in this country. This output was produced by some 41 establishments employing some three or four processes. Practically all these latter, however, with one exception, depend upon the production of nitric acid by the reaction of sulphuric acid upon Chile saltpeter; the one exception being the production of nitric acid from the nitrogen of the atmosphere by an electric arc. This process, however, has not been introduced, except experimentally, into this country, so that all of the nitric acid manufactured at the present time is made from Chile saltpeter and sulphuric acid. This method of manufacture is nearly 300 years old and was first used by Glauber in the sixteenth century. From that time to the present day the

The arrangement of the battery is such that the gases on issuing from the still are promptly condensed in a receiver (or tourill), *A*, and six long water-cooled pipes, *B*, connected at the top by 180° bends. These tubes are maintained at such a temperature by means of a box filled with water that the amount of water contained in the gas from the still is reduced to a minimum, and the nitrous acid and chlorine in the gas remain uncondensed. These latter pass through the condensing tubes to the absorption tower, *C*, the temperature of which latter is in turn so regulated that the chlorine and some of the water passes through the tower, while the nitrous acid, which has been almost completely oxidized to nitric acid in its passage through the tubes to the tower by a current of air, introduced at *d*, is retained by the water used in the tower. The amount of nitrous acid so carried over

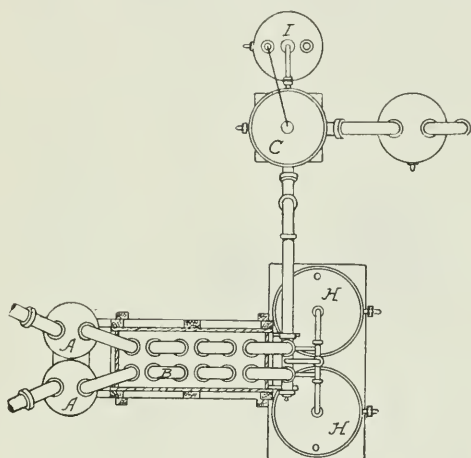
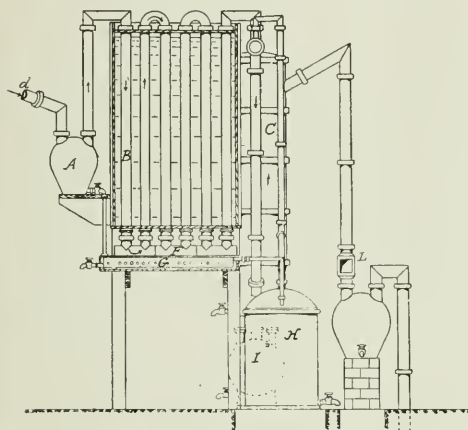


Fig. 1.—Elevation and Plan of Nitric Acid Condensing Battery.

improvements, therefore, have all been along the line of better apparatus for carrying out the reaction.

The still used has retained very much the same form for many years, although of late somewhat larger stills have been employed, and the actual advances have all been in the line of improved condensing appliances. The object in nearly every instance, has been to secure a condensation of the nitric acid with as little water, chlorine and lower oxides of nitrogen contaminating it as possible. A number of apparatuses are now being successfully used in this country for this purpose.

One of the most used of these condensing batteries is that of Oscar Guttmann¹, which he first devised some 15 or 20 years ago and described in the *Journal of the Society of Chemical Industry*, in 1893. Since that time the apparatus has undergone a number of improvements and in its present form it is shown in the accompanying illustration, Fig. 1.

and caught in the tower amounts to about 5 per cent of the total yield. This is recovered by being again charged into the still.

In order to obtain the results mentioned above it is necessary that the nitric acid be removed from contact with the uncondensed gases as soon as it condenses, and this is accomplished in the new Guttmann apparatus by means of drain pipes attached to the lower extremities of the connecting elements, *F*, which join the upright tubes. The connecting elements, three in number, are each made to connect two upright tubes only, which forces the gas to pass up one pipe and down another, etc. In the old batteries, the acid was conducted into the storage vessel by means of U-tubes which passed under partitions in the connector, but in the new battery each compartment has a drain pipe, which conducts the acid from the compartment into a tubulous cooling channel, *G*, leaving a free passage for the gases. The drain tubes dip into acid in the cooling channel and this prevents the gases from short circuiting and forces them to go through the upright

¹This apparatus is now made in this country by the Didier-March Co., 50 Church St., New York City, who have just built a large factory for the manufacture of such apparatus at Keasbey, N. J., using therein clay, which they import from Germany.

tubes. From the cooling channel the acid runs into the storage vessel, *H*. Any gases evolved in this latter are conducted to the tower.

When it is desired to thoroughly bleach the acid, a little compressed air is heated to 80° C. by passing through an iron coil placed in the flue of the still and blown into the acid in the storage vessel. When bleached in this way, the cooling water in the cooling channel has to be so regulated that it has a temperature of at least 50° C. on leaving the cooler. The draft of the apparatus is controlled by means of the lantern, *L*, which is provided with holes which are closed as needed by means of balls or plugs. Fig. 2 shows this lantern in detail.

A battery of six pipes will easily condense the distillate obtained from a charge of 2,000 pounds of nitrate of soda. The whole of the acid produced is of one strength so that no blending or mixing is necessary. The battery may be used for the manufacture of acid of any desired strength, this depending largely on the strength of the sulphuric acid used to charge the retorts. Where a strong acid having a specific

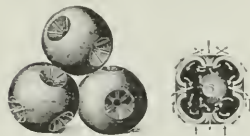


Fig. 3.



Fig. 2.

gravity of 1.504 is desired, it is usual to charge the retort with about 2,000 lbs. of 96% sodium nitrate and 2,420 lbs. of 66° Bé. sulphuric acid. About 1,644 lbs. of nitric acid of 1.504 specific gravity will be produced. Where nitric acid of 1.42 specific gravity is desired, the charge is usually 2,000 lbs. of 97% sodium nitrate and 2,536 lbs. of 60° Bé. sulphuric acid. The yield in this case will be about 2,300 lbs. of acid. Where it is desired to use waste acid, such as that from the manufacture of gun cotton, containing approximately 10% nitric acid, 80% sulphuric acid and 10% water, 2,052 lbs. of this acid, 585 lbs. of 66° Bé. sulphuric acid and 2,000 lbs. of 90% of sodium nitrate are employed. The product from this charge will be nitric acid of 1.506 specific gravity. When manufacturing an acid of 1.42 specific gravity, it can be obtained water white with this battery and usually free from chlorine and sulphuric acid.

The absorption tower of this apparatus should, of course, be efficient, as about 5% of the acid escapes from the tubes. A tower filled with Guttman's hollow balls, such as are shown in Fig. 3, will serve admirably to catch this acid, a tower of 100 ins. diameter and 10 ft. high being sufficient for four stills of 2,000 lbs. capacity. The circulation of the liquid through

the tower is obtained by means of the air lift, *I*. At first water is poured in, but as it passes through the tower it gets stronger with every pass, until an acid of about 1.34 sp. gr. is obtained, which is drawn off and used in the charging of the still, the lift being again filled with water.

The Guttman batteries are usually made in double sets, that is, two batteries of six pipes each are mounted in one water tank. Two of these double batteries may be connected to each tower 28 ins. in diameter and 10 ft. high. Each battery will take care of two stills, so that the equipment of a small plant will be something like 4 stills, 2 double condensing batteries of 6 pipes each and one tower filled with Guttman balls.

The battery frame should be mounted on a concrete foundation. The base for the collecting vessels, towers, etc., should be of brick laid in cement. The surface of these bases, however, should be made smooth with cement. The tower should rest on a well worked ring of sandstone of 26 ins. outer and 18 ins. inner diameter and 4 ins. thick. All woodwork should be tarred to prevent attack by the acid fumes.

An important thing in the setting up of this apparatus is, of course, the cement for the earthenware joints. This is usually composed of one part of sodium silicate solution (140° Tw) and 10 parts of water. With this is mixed asbestos powder till a stiff paste is formed, which can readily be broken up by hand. If a harder cement is desired, a little powdered heavy spar may be added. The objection to this, however, is that if much heavy spar is used it is difficult later on to remove the cement for repairs, substitutions of broken parts, etc. The amount of water should not be smaller than that directed, as otherwise the cement will absorb moisture from the air and burst the pipe sockets. In erecting the apparatus, the sockets are first moistened with a solution of sodium silicate, the cement is then introduced in small pieces, and well pressed down with a flat piece of wood. After the socket has been filled up, the surface is smoothed with a solution of sodium silicate. When a joint begins to leak about one-half inch of this cement is removed and replaced.

It is recommended that the tower, the storage vessels, and other large and prominent joints should be only one-half filled with the cement, and after drying covered in with pure cement. The sockets at the exit end of the tower and other places subjected to much wear are similarly made tight and covered on the outside with a thick layer of pure cement.

When erecting the battery the cooling channel should be placed horizontally, the pipes vertically and the conduits should slope at least 5 ins. in 100.

For making the stuffing-box joints of the tubes, at the under side of the water tank, a good greasy cord packing is required. The outer diameter of the packing ring is 534 ins. Lead washers should be placed

below the nuts inside the water tank, and the nuts not screwed down too tightly, so as not to burst the pipes.

For the acid elevator, air at 30 lbs. pressure, admitted through $\frac{1}{4}$ -in. valve is sufficient, and $\frac{1}{4}$ -in. glass tubes are used for the acid, which is circulated through the tower until an acid of 1.34 to 1.36 specific gravity results. This is then drained off and at the next charging of the retorts added to the latter and distilled again.

The firing of the retorts should be gradual so that the pipes are slowly warmed up. For the heating of the apparatus about 250 pounds of coal per charge will be needed. Three men will be required for eight stills. The space occupied by the apparatus is about 65 sq. ft. for the two batteries, depending somewhat on the arrangement.

EXHIBIT OF CHEMICAL ENGINEERING APPARATUS AT THE PITTSBURG MEETING OF THE AMERICAN INSTITUTE OF CHEMICAL EDGINEERS.

(Continued from February Issue.)

GEORGE M. NEWHALL ENGINEERING COMPANY, LTD.

The exhibit of the George M. Newhall Engineering Company, Limited, 136 South Fourth St., Philadelphia, Pa., consisted of a number of beautifully made blue line prints, showing their evaporators and also the layout of a wood-fiber paper mill.

The first of these drawings, entitled "A-1177, Newhall Evaporator, complete setting, triple effect, front and side elevations," represented a typical Newhall evaporator as designed to be used on cane juice, beet juice, glucose, extracts, etc., and the complete equipment here is composed of three equal effects containing equal amounts of heating surface, one Bukley condenser with barometric leg pipe reaching to the hot well which was also shown; one Duplex pump for removing the water from the hot well; one fly-wheel pump for the removal of the water of condensation; two steam traps to prevent the equalization of pressure between effects, during the continued removal of condensation from water boxes connected with the heating surface. Effects were shown as equipped with all necessary piping and mounting, which include safety valves, combined pressure and vacuum gauges, sight glasses for observing the boiling, man-holes giving access to the interior, etc.

The second drawing, entitled "A-1179, Newhall evaporator, oblong type, double bank," showed the detail construction of one effect of an evaporator in use working on cane juice. The bottom floor of the effect is $\frac{1}{2}$ -in. steel, equally spaced on rivet centers. The interior floor of the upper bank of tubing is of the same thickness and supported on 5-in. I beams. Interior bracing of the walls, which are of $\frac{1}{2}$ -in. boiler steel, is accomplished by the use of angle irons as struts, attached to vertical angles and gusset stays, riveted to the inside of the walls. In the front end of the evaporator, there is an outside vapor space con-

necting the vapor space lying between the lower bank of tubes and the floor of the upper bank of the vapor drum above. The idea in this evaporator is to accomplish practically twice the amount of evaporation for a given size effect by the use of two banks of tubes. The vapor drum above the upper bank is amply large enough to take care of the vapor without entrainment. The floor of this bank acts as a baffle against entrainment of the lower bank, whose vapor passes through the side vapor spaces and is emitted just under the uppermost baffle of the effect. The actual running of the double bank evaporator is giving the very best results especially where there is no tendency towards foaming of the liquor.

The third drawing, "A-1206 Newhall Caustic Brine Evaporator," illustrated an evaporator applicable to the evaporation of substances such as salt, sodium carbonate, sodium bichromate, and in fact, any liquors which tend to precipitate crystals during evaporation. The drawing shows detail of the construction which consists of the ordinary type of evaporator with the exception that the sides of the shell are brought together with two heads, into a square or rectangular hopper, beneath the heating surface. To the bottom of this hopper is attached a producing nozzle made of cast iron and leading to a valve through which the salt may be precipitated. This system of precipitating salt in an evaporator and passing it through a receiver and strainer has been worked out to a very successful finish.

Another drawing, "A-1200, Newhall Triple Effect Evaporator—Details of Shells," showed liquors or any chemicals which tend to foam. The bank of heating tubes is quite high and reaches approximately to 40% the height of the effect. It is the nature of certain caustic soda liquors and black liquors in pulp mills and others to foam to a considerable extent, hence the provision is made in this evaporator for the heating surface to extend a great way above the level of the actual liquor. The idea here is that the upper tubes act as foam-killers and at the same time evaporate the liquor of which the foam is composed. It has been demonstrated that the efficiency or evaporative work per square foot of heating surface, is as great where the heating surface acts on the foam as where it acts on the solid liquor. This drawing mentioned shows the complete steel construction throughout. The bracing of the flat surface of the side walls is accomplished by the use of channel irons as struts, attached to the walls with angles and gussets. This is practically the only type in which it has been definitely demonstrated that there is no loss of solution when working on black liquor or caustic soda.

Another print, "B-1016, Newhall Evaporator, double effect, complete setting," was a typical drawing, as in the case of A-1177, showing the smaller outfit as used for the recovery of copper from pickle waste, and for other chemicals, the only difference being in the use of the oval type of effect instead of the flat bottom. This is the design for smaller scale work

that has usually been accomplished with multiple effect evaporator.

The last drawing gave the layout recently gotten up of a southern paper company to be operated on a 30-ton basis, turning out wrapping paper. The equipment shown consisted essentially of chipper, chip-screen, welded digester, wash pits, blow pits, black liquor tanks, multiple effect evaporator, chip bins, causticizing pans, settling tanks, waste heat boiler, leach pans, rotary incinerators, steam boilers, octagon washers, wet machines, stuff-chests, beater engines and Fourdrinier machines.

Fig. 8 illustrates "Newhall" evaporators as built for use in soda pulp mills, chemical works, etc. Fig. 9 shows a "Newhall" Evaporator, of 150,000 gallons per 24 hours rated capacity, installed at the mill of

automatic monteju, which was described in an article on "The Moving of Liquids" in our November issue. This apparatus was shown working, and its efficiency was demonstrated by the representative in charge. To a tank in one side of their exhibit a number of spray nozzles (Fig. 10) were attached, and these were shown in operation. These nozzles are used for a great variety of purposes, and are made of such sizes as are needed and of such material as best withstand corrosive influences. These nozzles are made to throw either at a wide angle for atomizing purposes, or at a more acute angle for cooling purposes. Among the uses of these atomizers may be mentioned the spraying of coal dust in coal mines, as it has been found that the greater the humidity the less cause for explosion. The nozzles have also been used for spray-

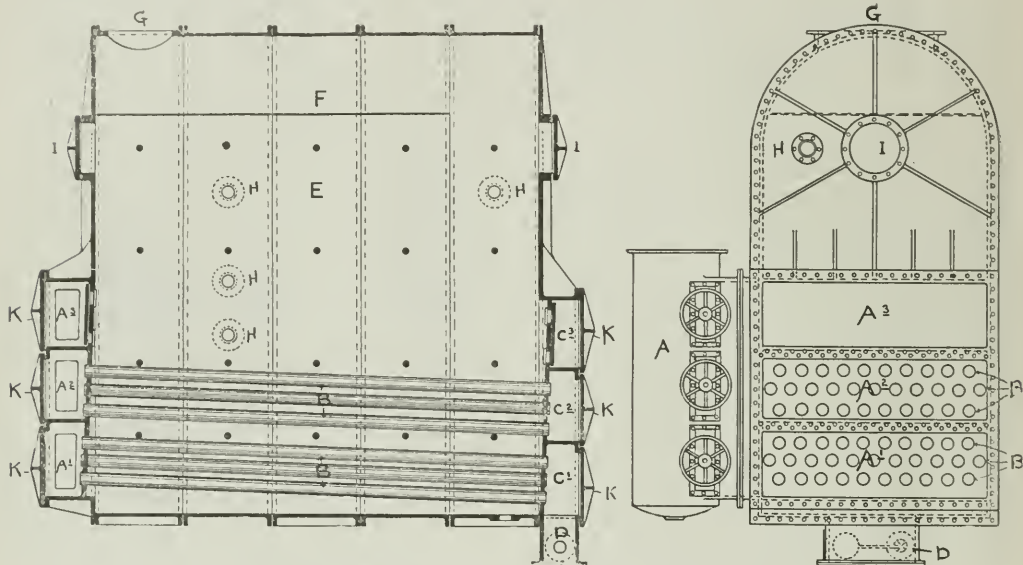


Fig. 8—Newhall Evaporators, George M. Newhall Engineering Co., Ltd.

the Oxford Paper Co., Rumford Falls, Me. This evaporator, however, proved to have an actual capacity of 20% more, or 180,000 gallons. Referring to Fig. 8, H is the steam trunk from which steam is drawn, A1, A2 and A3 are compartments from which steam is admitted to the tubes, B and C. The water of condensation runs down these sloping tubes to the boxes C1, C2 and C3 and from there to the trap D. E is the vapor space above the boiling liquid and F is a plate separating the latter from the opening G. I is a manhole, and K K K, etc., are removable covers to the steam boxes. H H H, etc., are sight glasses to inspect boiling conditions.

SCHUTTE & KOERTING CO.

The Schutte & Koerting Company of Philadelphia, Pa., had on exhibition some of their well-known apparatus for the chemical and allied industries. Occupying the most prominent place of this exhibit was the

ing oil on wool, for getting rid of suds which collect on the plates of paper machines, thereby permitting the equal distribution of the material on the wire cloths. They have been employed to absorb the vapors of lacquer and in chemical factories for condensing the vapors of a great number of volatile chemicals. They are used to precipitate the dust in cleaning blast furnace gases, particularly in the steel industry, and for washing crude oil in refineries. In chemical plants, these nozzles have been very extensively used for the injection of water into the lead chambers of sulphuric acid plants, for the absorption of acid fumes. The output of a sulphuric acid plant using spray nozzles is greatly increased compared with the old system where steam was injected into the chambers, for the reason that the steam condenses very slowly, particularly in warm weather, thus reducing the output. The treatment of sulphuric acid with nitric acid in Glover

towers also numbers among the many applications to which these nozzles may be put.

The Schutte & Koerting Co. also had on exhibition their noiseless water heaters (Fig. 11) for heating liquids in vats by means of steam, which have been found of use in a great many industries. These heaters consist of two cone-shaped plates, one of which is perforated and the other of which is solid. The heater discharges in the form of an inverted cone, offering a large surface and thus causing rapid condensation. If water is to be heated to a temperature not exceeding 165°F., the air inlet on the heater is closed with a plug and nothing but the heater is needed, as it will be noiseless with from 5 to 100 lbs. of steam pressure

down only. The ball of the check valve is made of either earthenware or of hard rubber as desired. The acid syphons are used for elevating and transferring acid solutions, and are made of lead in an iron shell with a platinum steam nozzle, which latter feature greatly prolongs the life of the machine. They are also made of stone-ware, porcelain and iron, according to the nature of the acid to be handled. Where the diluting effect of steam is objectionable the automatic montejus above referred to, also their air-jet lifts, can be used to advantage.

DAVIS-BOURNONVILLE CO.

This exhibit was in charge of Mr. Henry Cave, President of the Autogenous Welding Equipment Co.,



Fig. 9—Newhall Evaporator at Mill of Oxford Paper Co., Rumford Falls, Me.

and above. If water is to be heated to a temperature above 165° and up to boiling point, then an air pipe with air to be supplied to the discharge jet, and by this admixture, prevent the formation of steam bubbles, which otherwise, in rising to the surface, escape and collapse, and thus cause noise. Thus water is heated in less time and with less expenditure of steam than could be done by the use of a perforated pipe. The air is proportionate to the depth of the water in the tank above the apparatus.

The Schutte & Koerting Co. also had on exhibition their automatic eductor, lead-lined stop valve, lead-lined check valve and lead-lined syphon. The lead-lined stop and check valves are lined throughout with lead. The construction of the stop valve is such that the spindle does not turn, its movement being up and

of Springfield, Mass. The latter concern represents the Davis-Bournonville Co., of New York, in the New England States. The exhibit consisted largely of a demonstration of the use of oxy-acetylene cutting and welding torches and various samples of welds made with the apparatus and a number of photographs of emergency repairs which had been carried out by their use. The exhibit attracted a large amount of interest and whenever Mr. Cave was demonstrating he was surrounded with a crowd of interested chemists. The apparatus which he used consisted of a torch in which the heat is produced by burning acetylene with pure oxygen. The torch is shown in Fig. 12. This can be varied by the use of various size tips from a flame 1-16 to 1/4-in. in diameter. The flame has a temperature of about 6,300°F., which is about the same as

that of the electric furnace, and, upon its application to any metal, fusion soon takes place; which is noted by the operator, who wears darkened glasses to enable him to guide the movement of the torch.

The most important factor in the apparatus is, of course, the torch shown in Fig. 12. The upper pipe carries the oxygen, which varies in pressure from 8 to 30 lbs. per sq. in., the variations in pressure being due to the different sizes of tips used, according to various thicknesses of the metal to be cut or welded. The lower pipe carries the acetylene gas at a pressure of about 1 lb. per sq. in., a regulator reducing the pressure from 15 lbs. in the tank. The oxygen enters the tip through the small opening in the direct line of the flow, while the acetylene enters through four openings drilled at right angles to the line of flow. These

in first heating the metal, by using the welding flame only, to about 6,000 F., this at the point of starting the cut. When this temperature is reached, as will be evidenced by the color of the metal, an additional stream of pure oxygen is turned on from a second oxygen reservoir, the pressure in which is varied from 125 lbs. to 175. per sq. in., according to the thickness of the metal to be dealt with. The result is a chemical union of the oxygen and the carbon of the metal, the additional oxygen causing a disintegration of the metal. The force of the blast carries the disintegrated metal before it, and as the torch advances, a narrow opening, or cut, results. The accompanying illustration, Fig. 13, shows the cutting tool being moved upward. By referring to Fig. 12 it is seen that the additional oxygen pipe is not an integral part of the torch,



Fig. 10—Spray Nozzle.

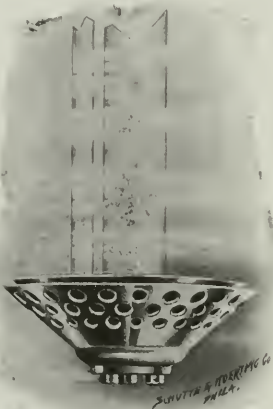


Fig. 11—Noiseless Water Heater.

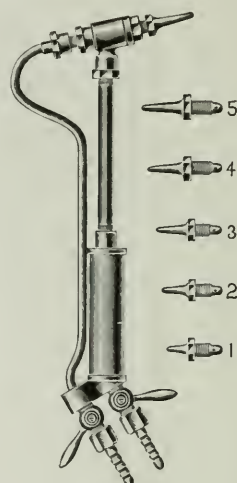


Fig. 12—Cutting and Welding Torch.

openings are accurately bored to admit the proper proportions of the gas, but in addition to this the operator throttles the flow of the gases into the torch to obtain the required flame. The tips seen in the cuts are inserted into the head of the torch, the back end of the tip forming a ground joint with the oxygen conduit. The acetylene ports are inside the head. The mixing chamber, of very small diameter and from 1 to 2 in. long, is within the tip, and the mixture of the gases takes place within the tip instantaneously, with the combustion just outside of it. Stoppage of the flow of the gases will cause "flash-backs," but this never occurs to any serious extent in the form of torches shown. The enlarged portion of the acetylene pipe forms a convenient handle for the torch and also provides a chamber, packed with porous material, through which the acetylene supply must pass. This porous material also would prevent the flame being carried back into acetylene hose in the event of a flash-back.

The action in cutting is a chemical one and consists

but is temporarily clamped to it. From Fig. 13 it will be seen that the oxygen follows the oxy-acetylene flame.

There are two distinct forms in which the acetylene gas may be used, one the so-called dissolved acetylene, and the other in which the gas is used direct from a generator. Mr. Cave in his exhibition used dissolved acetylene, which is the gas absorbed in acetone. This liquid will take up about 25 times its own volume for each atmosphere of pressure. The steel tanks or storage vessels are filled to about 80 per cent of their volume with a porous material, after which acetone is poured in and the acetylene is then compressed into these tanks under a pressure as great as 150 lbs. per sq. in. The dissolved acetylene is more desirable for portable uses, but the generator is the cheaper of the two. The generator is capable of generating acetylene direct from carbide in pressures up to 15 lbs., and uses lump carbide, which yields from 5 to 15% more gas than the finely crushed. It consists mainly of a large vessel filled with water. The lump

carbide is dropped into this latter from a hopper, being fed automatically by a mechanism which is controlled by a pressure diaphragm. When the gas is drawn from the generator for use a drop in the generator pressure results, and when this goes below a certain fixed point the automatic mechanism feeds additional carbide into the water, which, of course, generates more gas and increases the pressure.

Mr. Cave demonstrated the use of the apparatus for welding purposes upon both cast iron, steel and aluminum, and also welding cast iron and copper to steel.

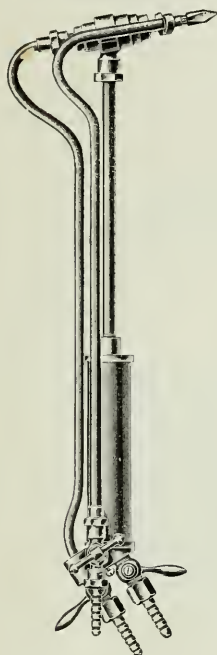


Fig. 13—View Showing Cutting Tool of Torch.

He also cut a steel plate and demonstrated the heat of the flame by applying it to a fire-brick which almost immediately began to flow. Among the specimens of welding which he displayed was a motor-cycle combustion head which had had part of the flange welded in and metal added to strengthen the exhaust part, thus saving the necessity of having a new pattern and casting made. He also showed a pressed steel globe valve, the parts of which had been welded up by his process. Owing to the fact that the thickness and the strength of all parts of this valve are known, it would make a very suitable one for high pressure work. As showing the control which the operator has over the heat, Mr. Cave had on exhibition a number of catalogues with holes punched in them, through which steel rings were inserted, the joints of the rings being welded without even scorching the paper. A sample was shown of sheet steel, nickel-plated, and welded

up along the seams. This method is now used for the seams of the containers of the Edison storage battery. The fact that the nickel flowed over the weld, plating it. The non-oxidizing nature of the flame is shown by automatically.

A NEW FORM OF TUBE MILL.

By H. W. HARDINGE.

One of the most difficult problems that has presented itself to the metallurgical engineer has been the fine crushing of material to be reduced to the extreme division of mechanical economy. The cost to reduce almost any material, and pass the last 10% through a 100-mesh screen—provided it is done in the same crushing medium—is about equal to the cost of reducing the first 90%.

I believe that it will be conceded by engineers who have this problem before them, that the tube or pebble-mill has more nearly reached the economic point than any other divisional device—but even this most efficient machine has its objections in the enormous con-

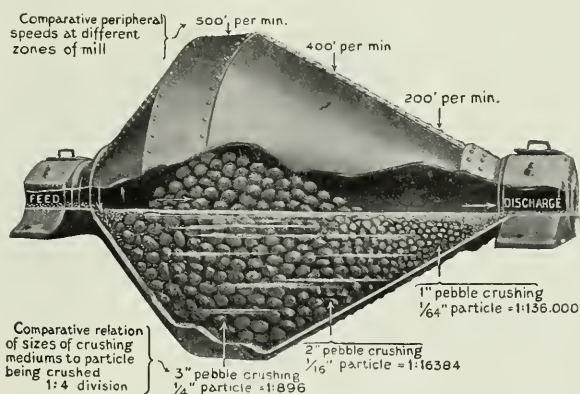


Fig. 1—Hardinge Conical Mill.

sumption of power, its weight, size and inability to successfully control the product.

It was to overcome these difficulties—which I, myself, encountered for years—that gradually brought about the production of what is now known as the "Hardinge Conical Mill." The chief principles involved are the utilization of well-known physical laws of mass and gravity, and adjustment of the size of crushing body to the particle to be crushed.

It is a well understood principle in crushing mechanics, that a reduction of 4 to 1 in the same medium is about all that can be economically obtained. In the production of the conical mill these principles have been kept constantly in view.

A study of the accompanying cut, Fig. 1, will illustrate how this object is attained.

The conical mill as described in the patent is a device wherein the larger crushing bodies arrange them-

selves at the greatest diameter of the cone, the smaller pebbles gradnating, according to their sizes, toward the outlet or apex of the cone, seeking and maintaining positions in gradually reducing zones or diameters of the cone.

In this device an even higher efficiency has been obtained than can be readily figured, for it is difficult to understand why the fine material seeks a higher elevation than the coarser sizes of the same material, but such is the case, the action of the apparatus being, that upon successive rotations of the cone the crushing bodies size themselves from the inlet or feed end to the outlet end of the apparatus, in the same manner that the material to be crushed sizes itself in passing through the interstitial space between these crushing mediums. For instance, if $\frac{1}{4}$ " material is fed, it will be immediately subjected to the impacts of the larger pebbles, is subdivided, and according to the size of the division, passed along to the next succeeding smaller size of pebbles, where again successive divisions are made until the outlet or issue-end is reached.

In the older style of pebble mill there is no sizing action of the several tons of pebbles indiscriminately distributed throughout its length. It is conceded that a large portion of the material fed to such a mill is within the first two or three feet crushed to the final degree desired by the operator. This is due to the fact that not only are large crushing mediums disposed at this point, but smaller ones as well. The finished material must therefore work its way through 20 or more feet of unfinished or partially ground material and pebbles of all sizes, interfering with the action of these pebbles by presenting a cushion of material, absorbing power by simply pressing without crushing.

In the conical form of mill, with one ton of pebbles and 15 h.p. we have produced the same amount of material of a desired size as produced with three times the power and five to eight times the amount of pebbles in the old-style regulation tube-mill. In the conical mill the energy is consumed in the reduction of the particles without the above mentioned interference. The greater percentage of power in the tube mill is consumed in compressive and frictional energy, the grinding of pebbles upon one another, and the production of heat.

A test was lately made by the representative of one of the largest engineering companies in the world, by taking from a conical mill which had been in operation but a few hours, a definite number of pebbles from four sections of the mill, beginning at the largest diameter to the cone outlet. This test by actual weight showed the relative sizes of the pebbles to each other to be as shown by the following diagram. (Fig. 2.)

These pebbles of various sizes were charged into the mill through the manhole without reference to size or position, and upon rotation of the mill they mechanically took the positions above indicated.

From this it will be seen that we have been using

crushing mediums relative in size to the particle to be crushed, i. e., we are using a sledge hammer to crack a walnut, a nail hammer to crack a hickory nut, and a tack hammer to crack a hazel nut. We are not wasting the energy of the sledge in cracking the hazel nut, nor endeavoring to crack the walnut with the tack hammer.

The simplicity of the device has many times brought out the question as to why so simple and efficient a device should have been so long overlooked, which question also applies to myself, as it was nearly ten years after my first use of the old-style tube mill before I conceived and adapted the principles involved in the Hardinge Conical Mill.

Not only has the conical mill been used for extremely fine dry grinding, as of cement, and sliming for cyanide practice, but it is being used to produce coarser size material for concentration. This regula-

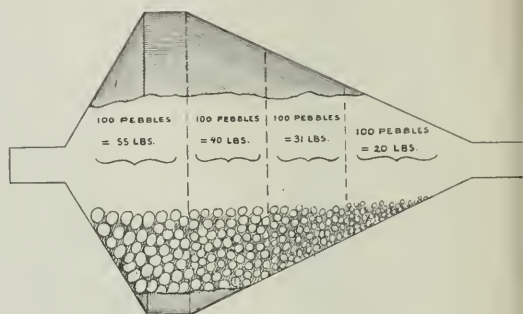


Fig. 2.—Test Showing Relative Size of Pebbles.

tion of size can be obtained by any one of four methods.

A point that will be appreciated by engineers is that material can be reduced wet or dry and as coarse as $\frac{1}{4}$ " without choking the mill.

The Hardinge mill can be arranged singly or in tandem, and for cyanidation while crushing affords the greatest possible aeration.

No less than eleven reasons have been assigned for the peculiar sizing action of the device, which has resulted in much scientific speculation as to the main or prime cause.

Dr. Eugene Haanel, Director of Mines of the Dominion of Canada, has just returned from a trip to Europe. While there, he made a careful investigation into the production of gases from peat, and, as the result of his investigation, the Canadian Government has appropriated \$15,000 for the erection of a fuel testing plant at Ottawa. The machinery for this plant has been purchased in Germany, and it is designed to test the quality of Canadian peat for the generation of gas. A peat bog will also be purchased by the government for use in these experiments.

AIR COMPRESSOR FOR PUMPING ACIDS.

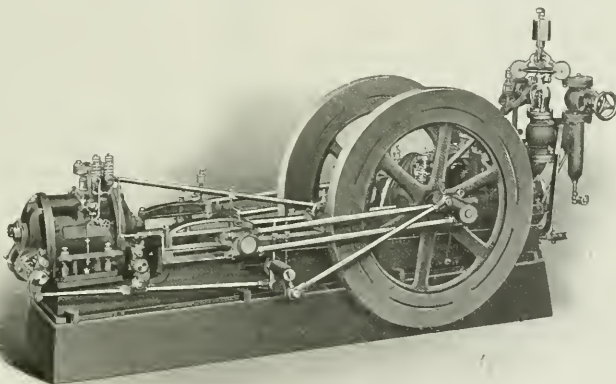
The accompanying illustration shows an air compressor that the Norwalk Iron Works Co., South Norwalk, Conn., built for the General Chemical Co. for the purpose of elevating chemicals by pneumatic pressure.

This machine has a single air cylinder and a single steam cylinder. The air cylinder is surrounded by a water-jacket and has Corliss inlet valves which are driven positively from the main shaft. The discharge valves are of drop-forged steel. The inlet valves are under the command of an air control which at a pre-determined point unhooks a latch between the driving mechanism and the valve, thereby holding the air valve wide open and allowing the air to pass in and out to the atmosphere without being trapped for the purpose of compression. This unloads the machine.

The steam cylinder has adjustable steam expansion valves and also a fly ball governor. This fly ball governor is fitted with a change speed mechanism, and this mechanism is in turn under the command of another

Aluminum can be soldered by means of the various special solders now on the market, but as such soldered joints are all more or less subject to electrolytic action in the presence of moisture, they are only suitable when protected from damp air. Welded joints, being entirely of aluminum, do not suffer under these conditions, and this method is being more extensively used now that satisfactory welded joints can be made by means of portable oxy-acetylene blow-pipe equipments.

It had long been recognized that this was the most hopeful direction in which to experiment, because such joints, containing as they do nothing but aluminum, would be as free from electrolytic action as the metal itself, but the difficulty met with was in getting rid of the film of oxide, which prevented the two surfaces uniting properly. In the case of the butt welding of small rods and wires, this difficulty can be easily overcome by applying end and pressure at the moment of fusion to drive out the film of oxide, but in the case



Air Compressor for Elevating Chemicals by Pneumatic Pressure.

air control. When the air reaches the pre-determined point, the air control allows pressure to come upon the change speed mechanism, changing the relative speed of the governor and thereby slowing down the compressor.

In tandem with this first air control is the second air control which has command of the unloading air cylinder mechanism. If, after the machine slows down, the air pressure still continues to rise, the second air control unloads the machine entirely as previously described, and thereafter the machine runs at a slow speed without pumping any air but sufficient to keep the pipes and cylinders free and clear of condensed water of steam, ready for immediate starting up to full capacity and full pressure as desired.

The exports of copper sulphate from the United States for the year 1908 amounted approximately to 7,663,882 lbs. This amount of salt is equivalent to nearly 2,000,000 lbs. of metallic copper.

of sheets and plates this method is not practicable, and recourse had to be made to some other method. Lately several fluxes have been put on the market capable of dissolving the film of oxide and permitting the metal to flow together with perfect ease.—J. T. W. Echarri, before Inst. of Metals.

The Sandusky Portland Cement Company, who have been supplying Standard Ottawa sand for cement testing purposes according to the specifications adopted by the American Society for Testing Materials, have turned over their business of preparing this sand to the Ottawa Silica Company, of Ottawa, Ill. This concern is prepared to make prompt shipments of this standard testing sand, packing the same in strong canvas bags, holding 100 pounds. This latter company has installed a special plant to take care of the demands of the cement testing business, and all orders sent to them will receive careful attention.

THE CHEMICAL LABORATORY

THE VALUATION OF PAINTS.

Blue Pigments.

Prussian Blue and Ultramarine.

To distinguish between these blues, place a little of the sample in a test tube and add hydrochloric acid. If hydrogen sulphide is given off the pigment is ultramarine. Place a small sample in a test tube and add caustic soda solution. If the color is destroyed the pigment is Prussian blue.

PRUSSIAN BLUE.

This pigment can best be tested by means of the strength test, comparing the sample under examination with a standard Prussian blue. Prussian blue is sometimes adulterated with china clay, barytes and starch. To test for the latter, boil the sample with water, allow to settle, filter and add a solution of iodine in potassium iodide to the filtrate. The formation of a blue color indicates starch.

Pure Prussian blue is soluble in hydrochloric acid, barytes and china clay are not. Hence to determine these impurities, ignite 1 gram of the pigment in a porcelain dish at a temperature just high enough to decompose the blue without being high enough to render the iron insoluble. Cool, add 15 c.c. of hydrochloric acid, cover with a watch glass and digest for an hour on the water bath. At the end of this time, remove the watch glass, evaporate to a volume of 3 or 4 c.c., add hot water, digest on the water bath for 15 minutes, filter and wash. Ignite the residue over a Bunsen burner and weigh. Report as insoluble impurities. To determine the nature of this insoluble, fuse with 10 times its own weight of sodium carbonate, extract the fusion with water. Filter off the insoluble residue, and treat on the filter with dilute hydrochloric acid. If it dissolves add a few drops of sulphuric acid to the solution, boil and filter. Wash, ignite and weigh as BaSO_4 . Report as such. The difference between this weight and that of the insoluble residue may be considered as being china clay.

ULTRAMARINE.

This pigment is usually adulterated with china clay or barytes. To test for these compounds, treat one gram of the sample with 25 c.c. of dilute hydrochloric acid (1 : 1) in a porcelain or glass dish and evaporate to dryness on a water bath. Add 5 c.c. of dilute hydrochloric acid and 20 c.c. of water. Digest on the water bath for 15 minutes, filter and wash well with hot water. Ignite the residue until all carbonaceous matter is destroyed, using a platinum crucible. Moisten the residue with a drop or two of dilute (1 : 1) sulphuric acid. Add a little hydrofluoric acid and evaporate to dryness. This may be rapidly done by placing the crucible in an inclined position on the triangle and placing under it a low flame in such a

manner that the latter is under the upper part of the crucible. Ignite and weigh the residue. If more than 0.5 per cent residue is found the pigment is adulterated with china clay or barytes. To distinguish between the two proceed as in the analysis of Prussian blue by fusing with sodium carbonate, etc.

Red Paints.

Iron Oxide, Vermillion, Red Lead, Para Red, Basic Lead Chromate.

To distinguish between these pigments, place a small sample in a test tube and add alcohol, boil, allow to settle and decant the solution. A reddish or orange yellow solution denotes the presence of paranitraniline red, scarlet (2R) or eosine. Heat residue with water, allow to settle, pour off the water and boil the residue with very dilute ammonia. If either the water or ammonia solutions are colored organic coloring matters are present in the pigment. If an organic color has been detected the base may be barytes, whiting, china clay, red lead, orange mineral or zinc oxide. Test with hydrochloric acid; whiting, red lead, orange mineral and zinc oxide dissolve; barytes and china clay do not. To distinguish between china clay and barytes moisten a platinum wire with hydrochloric acid, dip into the sample and place in the flame; a green flame shows presence of barytes. If the sample dissolves in the acid with effervescence, whiting is present. To distinguish between zinc oxide and red lead add hydrogen sulphide, a black precipitate indicates red lead. To test for zinc oxide, add ammonia and then ammonium sulphide or hydrogen sulphide, a white precipitate indicates zinc oxide. Treat another sample in hydrochloric acid, dilute and to a small amount of this solution add ammonia in excess. A red brown precipitate indicates iron oxide. If the pigment is insoluble in alcohol or acid it is probably vermillion (HgS). To make sure of this, heat in a closed tube with charcoal and a little sodium carbonate, a sublimate composed of globules of mercury indicates vermillion.

IRON OXIDE.

This pigment is analyzed by methods similar to those for iron ores (see Blair's "The Chemical Analysis of Iron." Its value will depend upon its shade in oil, percentage of iron, the fineness to which it is ground, and freedom from grit.

Place two grams of the sample in a porcelain crucible and weigh. Dry for one hour at $100-110^\circ\text{C}$., cool and weigh. The loss in weight is moisture. Ignite for one-half hour at a low red heat, cool and weigh. The loss in weight represents combined water and organic matter. Report as such. Transfer the sample to a small beaker, add 25 c.c. of concentrated hydrochloric acid, cover with a watch glass and heat on the

water bath or hot plate (do not boil or ferric chloride will be volatilized) for several hours or until the residue is white. Remove the watch glass, add 15 c.c. of dilute sulphuric acid (1 : 1) and evaporate on the hot plate until dense white fumes come off, cool and add 100 c.c. of water. Digest on the water bath for 15 minutes, filter and wash, catching the filtrate and washings in a 200-c.c. flask. Ignite the residue and weigh as insoluble silicious matter and barium sulphate. To determine the barium sulphate, fuse with sodium carbonate, extract the residue with hot water, filter, wash, dissolve the residue in hydrochloric acid, dilute, boil and precipitate the barium with a few drops of sulphuric acid, etc. (See white pigments). Cool and dilute the contents of the flask to the mark. Remove 50 c.c. (0.5 gram of the sample) and determine the iron in this by reduction with zinc and titration with permanganate.

To another portion of 100 c.c. (1.0 gram of the sample) add sodium hydroxide solution until nearly but not quite neutral. If warm, cool by placing in water. Add zinc oxide emulsion until the mixture stiffens. Dilute to about 350 c.c., mix and let stand until the ferric oxide settles. Pour into a 500-c.c. graduated flask. Add a considerable excess of zinc oxide and dilute to the mark. Mix well, pour into a dry beaker, allow to settle, decant about 300 c.c. through a dry filter and funnel into a dry beaker, and measure out two portions of 100 c.c. each (0.2 gram of sample) into wide mouth Erlenmeyer flasks. Titrate the first portion roughly with potassium permanganate solution after heating to boiling. The other portion is then heated to boiling and titrated exactly. The MnO_2 value of the permanganate solution may be found by multiplying the iron value by 0.4657.

If necessary, determine the other bases, lime, magnesia, alumina, etc., as in iron ores, using a portion of 50 c.c. (0.5 gram of sample).

UMBER, OCHER AND SIENNA.

These owe their color to hydrated ferric oxide and small amounts of manganese dioxide. They are usually analyzed only for moisture, loss on ignition, iron and manganese, the method outlined above being used. If complete analysis is required the sample is analyzed as if it were an iron ore.

RED LEAD.

The value of this will depend upon the percentage of lead dioxide it contains. To determine this, weigh 0.5975 grams of the very finely pulverized pigment into a small flask or beaker. Mix in a separate beaker 1.2 grams of potassium iodide, 15 grams of crystallized sodium acetate, 5 c.c. of water and 5 c.c. of dilute acetic acid (50 per cent) and stir until the salts go into solution. Pour this mixture upon the sample and rub with a stirring rod until all of the lead dioxide is dissolved. Add 15 c.c. of water and titrate with N/10 sodium thiosulphate solution until the liquid is a pale straw color, add a drop or two of starch solution, which should turn the solution blue, and continue the titration until the blue color is discharged. One cubic

centimeter of N/10 sodium thiosulphate is equivalent to 0.01195 gram of lead, or 2% when a sample of 0.5975 is used.

Green and Yellow Pigments.

CHROME YELLOW.

This compound usually depends for its shade, which varies from lemon yellow to orange, upon the relative percentages of lead sulphate and lead chromate which it contains. The usual determinations made are for moisture, insoluble matter (barytes, china clay, etc.), lead and chromium, and sometimes sulphates.

For moisture heat 2 or 3 grams for two hours in an air bath at a temperature of from 100 to 110°C. The loss in weight represents moisture.

To determine lead, chromium and insoluble matter, weigh one gram of the sample into a 5-oz. beaker, and heat on a water bath or hot plate with 20 c.c. of strong hydrochloric acid for 15 or 20 minutes. Dilute to almost the full capacity of the beaker with hot water and boil. Filter, wash and ignite the residue, weigh and report as insoluble impurities.

Add 10 c.c. of dilute sulphuric acid (1 : 1) and evaporate until dense white fumes of sulphuric anhydride come off, cool, dilute and filter off the lead sulphate. Wash first with 2 per cent sulphuric acid and then after removing the filtrate with 80% alcohol 5 or 6 times. Dry, separate paper and precipitate, ignite the former in a porcelain dish, moisten the ash with a few drops of nitric acid and a drop of sulphuric acid, drive off the excess of acids, add the precipitate, ignite and weigh as lead sulphate. Multiply by 0.7359 and calculate as total PbO .

Heat the filtrate from the lead to boiling, add ammonia in slight but distinct excess and boil until the supernatant liquid is colorless. Decant the solution through an 11-c.m. paper and wash the precipitate by decantation several times. Transfer the precipitate to the filter paper, wash a few times, dry, ignite and weigh as Cr_2O_3 . The filtrate should be colorless. $\text{Cr}_2\text{O}_3 \times 4.2471 = \text{PbCrO}_4$, also $\text{Cr}_2\text{O}_3 \times 1.3154 = \text{CrO}_3$.

To determine sulphates, weigh one gram into a 5-oz. beaker and boil with 25 c.c. of strong hydrochloric acid and dilute to 100 c.c. with hot water. Heat to boiling if necessary and add ammonia in slight but distinct excess. Filter as directed above, acidify the filtrate, using one or two c.c. of dilute hydrochloric acid in excess, heat the filtrate to boiling and add an excess of barium chloride solution. Allow to stand over night, filter, wash, ignite and weigh as barium sulphate. Calculate to sulphur trioxide $\text{BaSO}_4 \times 0.3430 = \text{SO}_3$; also $\text{BaSO}_4 \times 1.3419 = \text{PbSO}_4$.

CHROME GREEN.

This is a mixture of Prussian blue, lead chromate and lead sulphate. Greens made by precipitating the ingredients together are superior to those made by mixing and grinding the blue and yellow pigments. To distinguish between the two, rub the pigment with oil and allow to stand, if the oil shows blue the green has been poorly made, and not by precipitation. A

microscopic examination of the dry pigment will also detect this. A badly made green will show yellow particles as well as blue and green, while a well-made pigment will show only green and blue particles, chiefly the former. The main chemical determination consists in determining the impurities. Walker (U. S. Dept. of Agriculture, Bureau of Chemistry, Bul. No. 100) gives the following method for doing this:

Place 1 gram in a small casserole, add 10 c.c. of water and sodium peroxide, a little at a time (about 1 gram in all), to oxidize the Prussian blue; add about 25 c.c. more of water and boil for some time, so as to decompose all of the hydrogen peroxide. Acidify with hydrochloric acid, boil, filter, and wash. Transfer the residue again to the casserole and boil with a solution of ammonium chloride (slightly alkaline) to dissolve the last trace of lead; filter, wash, ignite, weigh the insoluble impurities and determine their nature. They are probably barytes or silica.

Heat another 1-gram portion very gently in a casserole or small porcelain dish, and remove from the flame as soon as it begins to glow. The heating should be carried out very carefully, the object being to decompose the Prussian blue, but not to heat it enough to render the iron difficultly soluble. Allow to cool, add hydrochloric acid, and digest covered on the steam bath for an hour. As a general rule, this treatment brings everything except insoluble impurities into solution. Cool, dilute to 300 c.c. and pass in a rapid stream of hydrogen sulphide until all of the lead is precipitated; filter, wash with water containing some hydrogen sulphide, boil off the hydrogen sulphide from the filtrate, add bromine water to oxidize the iron, add ammonium hydroxide in slight excess; filter, dissolve the precipitate in hydrochloric acid, reprecipitate with ammonium hydroxide, filter, wash, unite the filtrates, and determine calcium and magnesium in the usual way.

Black Pigments.

Bone-black, Carbon-black, Lamp-black and Graphite.

Black pigments should be tested for oil by placing a few grams of the sample in a filter paper, moistening with ether and pouring 15 or 20 c.c. of ether back and forth through the sample several times, finally washing a few times with ether, and then allowing the ether to evaporate in a warm place. There should be no residue of oil.

Other tests are those for moisture, volatile matter, ash, and adulteration.

Dry 1 gram of the sample in a small (15 c.c.) platinum crucible at 100-110°C. for one hour and weigh. The loss in weight represents the moisture.

Place a tight-fitting lid upon the crucible and heat for seven minutes over a Bunsen burner. The flame of the latter should be about 20 c.m. high and the crucible should be about 7 c.m. above the burner tip. Cool and weigh. The loss in weight represents volatile matter and also fixed carbon burned in seven minutes. To determine the latter, again heat the crucible for seven minutes under *exactly* the same conditions

as formerly. The loss represents the carbon burned. The difference between the two losses represents the volatile matter. Remove the lid and place the crucible in an inclined position on a triangle and burn off all the carbon. Weigh the residue, which is the ash.

Black pigments are supposed to be carbon black in one form or another. They are sometimes adulterated with soft coal, Prussian blue, and magnetic oxide of iron. To detect the latter use the magnet. To determine Prussian blue, boil the sample with a 4% solution of sodium hydroxide, filter, acidify the filtrate with hydrochloric acid and add a solution of ferrous and ferric chlorides mixed. A blue precipitate will form if Prussian blue is present. To detect soft coal in graphite, determine the moisture and ash as determined above. The difference represents the total carbon. Now heat one gram of the sample in a Kjeldahl digestion flask with 30 c.c. of concentrated sulphuric acid for two hours, at a temperature about the fuming point of the acid. Cool, add water, filter, wash, dry at 100-110°C. and weigh. Now ignite until all the carbon is burned. The loss represents the carbon present as graphite and the difference between this determination and that of the total carbon represents soft coal.

In determining the ash of graphite, it will often be found advisable to use a one-half gram sample and burn off the carbon either by the use of oxygen or a good blast lamp.

The following table, which is taken from the *Petroleum Review*, of August 15, 1908, gives a good idea of the approximate composition of the crude oils from the different oil fields in the United States:

APPROXIMATE COMPOSITION OF THE CRUDE OILS OF THE							
Products.	UNITED STATES.						
	Appa- lachian. %	Lima- Ind. %	Mid- Cont. %	Gulf. %	Cal. %	Corsica- na %	Colo. %
Naphthas — gasoline, benzene, etc.	12	11½	11	3	6	7	3½
Fluinating oil	67	43	41	15	18	50	35
Lubricating oils (in- cluding grease)	12½	15	—	6	1½	—	2
Gas oil	—	—	25	45	—	—	—
Fuel oil (including acid oil, asphaltum oil and asphalt)	4	25	20	28	72	40	55
Paraffin wax	2	2	—	—	—	—	—
Total	97½	96½	97	97	97½	97	96½

The Tennessee Copper Company erected during the past year a large plant for the manufacture of sulphuric acid from the gases of its smelters. A great deal of experimenting was necessary in order to get the furnace and acid plant to work together. It was found that special care must be taken at all points to prevent the dilution of the gas by means of the outside air, which necessitated a radical change in the construction of the furnace tops. The successful and economical working of this plant will undoubtedly control the fumes to such an extent that they will no longer damage the vegetation in the neighborhood of the smelter, which has so long been a matter of dispute between the copper company and the farmers.

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

PUBLISHED MONTHLY BY

THE CHEMICAL ENGINEER PUBLISHING COMPANY

355 Dearborn Street, Chicago

Entered as Second Class Matter, Aug. 19, 1907, at the Post Office at Chicago, Illinois, March 3, 1879.

Subscription—United States, Cuba and Mexico - - - \$2.00
Extra postage to Canada 25c a year; to foreign countries 50c a year.

Remittances may be made by check, draft, or money order in favor of
THE CHEMICAL ENGINEER PUBLISHING CO.

All matter connected with subscriptions or advertising should be sent to
THE CHEMICAL ENGINEER PUBLISHING CO., 355 Dearborn street, Chicago.
Anything intended for the Editorial Department should be sent directly
to the Editor, Richard K. Meade, Nazareth, Pa.

NOTES AND COMMENTS.

SOME PROBLEMS FOR THE CHEMICAL MANUFACTURER.

President Roosevelt in a message to Congress, on January 22d, in discussing the conservation of resources, stated that "our mineral waste is about one-sixth of our products, or nearly \$1,000,000 for each working day in the year." The President evidently viewed the matter purely from the standpoint of the conservation of our resources at the mine and not from the standpoint of the *actual* amount wasted. When we consider that of all the coal mined, valued at more than \$600,000,000 in 1908, only 13 to 14 per cent is transformed into energy by even the best power plants, and that of this energy probably not 50 per cent is ever utilized in useful work, it will be seen that in this one item alone the loss far exceeds the figures given by the President. While it is true that we are wasteful and extravagant with our natural wealth, the indications are decidedly that we will not always be so. That we are rapidly progressing towards the fuller utilization of our resources there is no doubt.

At the present time the exploitations of our resources is in the hands of capitalists, and nothing short of confiscation by the government will change their methods of developing their properties. As improved appliances are invented and new processes are brought forth for utilizing waste products of all sorts, the manufacturers can usually be relied on to adopt both. The wasting of this material has largely been due to the fact that money has been invested rather to produce dividends, than to utilize waste products or conserve resources. When capital can be shown a process which will change a waste product into a marketable article at a reasonable profit above the cost of production and without large expenditures, it is safe to say that business men will be as much in favor of the conservation of resources as the most enthusiastic member of the National Commission.

It is perhaps not altogether amiss to step and consider some of the things which we have done recently along this line. First, there has been a determined effort to utilize many fuels, which 10 or 15 years ago would have been considered only fit for the dump. The gas producer has opened up the employment of lignites and other low grade coals for power purposes. Briquetting machinery recently invented has allowed

salvage from the culm piles in the shape of fuel briquettes. The enormous waste of gas in the blast furnaces of the country (equivalent to twelve million tons of coal per year) is being checked. In this matter the iron makers of Germany and Belgium have been far ahead of those in the United States. Two large plants for the utilization of blast furnace gas, however, have been recently built in this country; namely, those of the Lackawanna Steel Co., at Buffalo, and of the Indiana Steel Co., at Gary, Ind. At the latter point 200,000 h.p. will be available.

The development of another resource will largely assist in the conservation of our coal, namely the development of our water powers. The statement is made without contradiction that American rivers could be made to run every train, turn every wheel and light every lamp in the country. The development of many of these water powers, however, will entail an enormous expenditure of capital. It would seem that the correct solution of this problem is for the government itself to own and develop the water powers of the country. This would prevent their going into the hands of any monopoly. Already many water powers have been secured by various corporations. For instance, the papers tell us that John D. Ryan has secured power rights at Great Falls, Mont., which will amount to not less than 75,000 hp. The development of even our most important water powers would represent a saving of approximately 300,000,000 tons of coal per annum.

One of the most serious problems which confronts us is, of course, the destruction of the forests. This drain is one, however, which will become less and less each year. Concrete for dwellings, which heretofore have drawn heavily from the forests, is now coming more and more into favor, and it is probable that our children, even the poorer ones, will dwell in houses made of concrete. Another drain upon the forest is the manufacture of wood pulp. We can save the forests, however, and still have books and papers. Other sources of pulp stock are being continually investigated, and as our knowledge of the cellulose molecule increases, we will no doubt find out how to make pulp from all cellulose waste. Practically all the sulphur at the present time mined is employed by the paper mills. The supply of this material in this country at least is by no means inexhaustible, but when this is gone, some chemical engineer will no doubt discover how to separate and liquify the sulphur dioxide in smelter fumes. The liquid gas could be shipped to the paper mills in steel tubes.

There are many uses for which wood seems to be peculiarly fitted. One of these is for railroad ties. The life of these ties can be greatly increased by proper treatment, and nothing has proved quite so efficient for this purpose as coal tar creosote. The employment of this latter will not only help to conserve our timber resources, but also to encourage the saving of the by-products from coke manufacture. A large amount of wood is at the present time also used

for forms in laying concrete work. This will, no doubt, very soon be replaced by metal forms.

The adoption of the horseless vehicle has increased many times the consumption of rubber, and sources of the crude stuff are limited. A number of rubber substitutes have been invented, none of which seems to entirely take the place of the natural article. The problem, however, does not appear to be insurmountable. The achievements of chemists in the invention of synthetic camphor and indigo, would indicate their ability to find a substitute for rubber, if given time.

No metal is more useful than platinum, yet the supply is very limited. Crookes suggests the use of osmium, but the supply of this latter does not seem to be much greater than that of platinum. At the same time its use would probably double the available quantity of material suitable for uses to which platinum is now put. Platinum is now largely used for spark points in gasoline engines. For the latter, a nickel point plated with platinum promises a substitute for the solid platinum point.

The nitrate fields of Chile will soon be exhausted and our own Death Valley deposits, said to amount to 22,000,000 tons, will hardly supply the world's demand very long. Happily, however, the problem of the fixation of atmospheric nitrogen is now solved. Potash minerals are abundant and when Germany ceases to supply the world, our feldspars can be utilized. Borax and phosphates, however, are not so abundant as to warrant waste. For salt we have the sea when other deposits fail.

One of the greatest problems connected with the industrial plant is, of course, the utilization of its waste products. Some processes have depended largely upon their waste products for their success. We are told that but for the by-product, chlorine, the LeBlanc process for the manufacture of caustic soda would have long since been merely a matter of technical history. The Solvay process, on the other hand, which has largely succeeded the LeBlanc, gives as by-products, large quantities of both calcium chloride and calcium carbonate, no extensive use for either of which has up to this time been proposed. The attempts to make Portland cement from the calcium carbonate (alkali waste) have been unsuccessful, simply because more economical raw materials are at hand. Calcium chloride has been utilized in a small way for a large number of purposes. If it could be cheaply collected and dried, there is no question but that it would substitute satisfactorily for the gypsum used in the manufacture of Portland cement. The gypsum, however, costs only from \$2.00 to \$4.00 a ton at the mines, according to grade, and it apparently is impossible to evaporate the calcium chloride from the waste liquors at anything like this figure. Small quantities of calcium chloride are utilized for a number of purposes, such as laying the dust of roads, for the brine of ice machines, for making wall plaster, etc.

The electrolytic process for the manufacture of caustic soda does not appear to have been able to compete with the Solvay process. This has been partly due to the fact that the chlorine obtained must be sold in order to make the process pay, and the demand for this element is slight in spite of the fact that there are ample ways in which it could be employed. The manufacture of carbon tetra-chloride, which is being much used as a solvent, will utilize some of it, and the electrolytic detinning process, which promises to be the coming method of utilizing tin scrap, will use a much larger proportion, and may be the means of assisting the electrolytic soda process to a prominent place in our industries.

In the utilization of the by-products from the manufacture of coke, this country has as yet made no beginning of any magnitude. Recent reports from Pittsburgh, however, state that the Frick Coal Co. has abandoned work to cost nearly \$4,000,000 on the erection of 1,700 bee-hive ovens at Uniontown, and will substitute for them a by-product plant at Gary, Ind. Items of this sort show that our manufacturers are becoming alive to the utilization of waste products which have a marketable value.

Our manufacturers are even making some progress in the utilization of waste products, the discharge of which into the air or rivers is an annoyance to the people of the surrounding territory. Two such offensive wastes are the sulphite liquors from the manufacture of paper pulp and the smelter fumes from furnaces working upon sulphide ores. In the former instance, the dumping of the waste into the streams serves not only to poison the fish, but also to render the water unfit for drinking purposes. In many instances the mills are located at the head waters of streams which furnish drinking water for cities and towns. No solution of this problem has yet been found.

In the case of the smelter fumes, their destruction of vegetation has caused much litigation. While in most cases the smelters are not located in agricultural districts, it still seems advisable to devise some method of getting rid of the fumes without injury to surrounding vegetation. In certain parts of the West this has been done by means of very tall chimneys, which are designed to carry the gas far above the earth and discharge it among the clouds. The Tennessee Copper Co. has erected a 1,000-ton acid plant at Ducktown, Tenn., to manufacture sulphuric acid from the fumes from their smelters. The Ducktown Sulphur, Copper and Iron Co. have also in process of construction a large chamber plant for the manufacture of sulphuric acid. This company experimented with the contact process, but found it unsuited to their conditions. These plants are located near fertilizer works and hence can readily dispose of their product. The smelters of the West, however, are not so advantageously situated and probably could not dispose of any large amount of acid.

CHEMICAL SOCIETIES.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—Samuel P. Sadtler, Pres.; John C. Olson, Sec'y, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN CHEMICAL SOCIETY.—W. R. Whitney, Pres.; Charles L. Parsons, Sec'y, Durham, N. H.

SOCIETY OF CHEMICAL INDUSTRY, NEW YORK SECTION.—Maximilian Toch, Pres.; H. Schweitzer, Sec'y, 128 Duane St., N. Y. City. NEW ENGLAND SECTION.—F. E. Atteaux, Pres.; W. H. Walker, Sec'y, Box 1189, Boston, Mass.

WESTERN ASSOCIATION OF TECHNICAL CHEMISTS AND METALLURGISTS.—W. D. Engle, Pres.; H. C. Parmelee, Sec'y, P. O. Box 1421, Denver, Colo.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Charles B. Dudley, Pres.; Edgar Marburg, Sec'y, Univ. of Penn'a, Philadelphia, Pa.

AMERICAN ELECTROCHEMICAL SOCIETY.—E. G. Acheson, Pres.; J. W. Richards, Sec'y, Bethlehem, Pa.

AMERICAN LEATHER CHEMISTS' ASSOCIATION.—H. T. Wilson, Pres.; H. C. Reed, Sec'y, Stamford, Conn.

A meeting of the American Peat Society was held at the Chemists' Club, in New York City, on Saturday evening, February 13th, for the formation of a New York section of this society. A number of addresses by prominent speakers were made, showing what great wealth is now hidden in the thousands of acres of peat swamps at the present time almost worthless. Professor F. R. Stephens, conductor of the New York State Farmers' Institute, spoke upon the agricultural and industrial development of the peat lands in the state of New York, estimated at between 2,000 to 3,000 square miles.

Professor Charles A. Davis, of the United States Geological Survey, spoke of the peat resources of the United States, and Dr. O. Zwingenberger on the gasifying of peat. Mr. Herbert Philipp read a paper on the "Utilization of Peat for Fertilizers and By-Products," which was followed by a general discussion on various peat topics.

The International Congress of Applied Chemistry will meet in London in the week of May 27th to June 2d, 1909. Past congresses have been held in Brussels, Paris, Berlin, Vienna and Rome. An effort has been made to have the next congress, which meets in 1912, held in New York City. A meeting to take the initiative towards bringing about the holding of the next congress in America was held recently at the Chemists' Club, in New York City. A committee was appointed, of which Mr. W. H. Nichols, of the General Chemical Co., is chairman. Steps have been taken to induce the United States Government to officially invite the foreign nations to New York, and also to obtain the support and co-operation of all American educational institutions, scientific organizations, manufacturing corporations, and others likely to be interested in this congress. A meeting to further the cause will be held in the Chemists' Club, 108 West 55th St., New York City, on Saturday, April 3d, at 8:15 p. m., when the chemists of the country generally are invited to be present.

BOOK REVIEWS.

THE MECHANICAL APPLIANCE OF THE CHEMICAL AND METALLURGICAL INDUSTRIES. By Oskar Nagel, Ph. D. 8vo. Cloth. Illustrated. vii + 307 pages. Price \$2.00. Published by the Author, New York, 1908.

This treatise, modeled after Parnicke's German work, describes chiefly American machines, and covers the field fairly satisfactorily. The subject is too large for brief treatment, and the book does very well, considering the small space which the author has allowed himself. The theory of the various processes which the machine is to carry out is seldom entered into, and the book confines itself strictly to descriptions of the apparatus, with here and there a comment as to efficiency. For the most part the types described are of the best, but in some instances the claims put forward for them are rather those of the manufacturer than those of the conservative engineer familiar with the machine. An unfortunate feature is that there is a failure in each and every instance to mention the cost. We know that manufacturers are very much averse to publishing the cost of machinery. At the same time the practical engineer is very desirous of knowing just this fact, and where quick estimates on plants and processes have to be made, time is not always available for securing this information from the manufacturers direct. Another failure of the book is the lack of information as to the power required by chemical machinery, and the apparatus necessary to keep it in efficient working order. The book opens with a chapter headed, general, which deals almost exclusively with matter relating to pipes and valves. Chapter II is a brief discussion of steam and water power appliances. In this connection it seems strange that the author should describe the steam boiler and accessories and not the engine, the more so as other prime movers such as the steam turbine and water wheel are described, and Chapter III is devoted to the gas engine. Chapter IV on electric power seems to be devoted to an argument for motor drives, rather than an impartial discussion of their advantages, and likewise their disadvantages. Chapter V is an excellent description of conveying machinery for solids, and Chapters VI and VII are descriptions of conveying appliances for liquids and gas. In the latter, however, chimney formulae for power gases only are given, whereas in chemical works chimneys are very frequently used to convey noxious gases to a point where they are discharged in the atmosphere without any harm to surrounding vegetation. Chapter X on firing and furnaces deals rather too much with producer gas firing and rather too little with direct firing, and nothing at all with a coming method of firing, namely, powdered coal. This chapter is also poorly arranged, as it begins with gas firing, then describes the furnace, and then jumps back to water gas, direct firing, and oil. Among furnaces we note that neither the rotary cement kiln nor the gypsum

calcining kettle are mentioned. Chapter XI deals with separating appliances such as filter presses, centrifuges, vacuum filters, jigs, etc. This chapter also is an example of bad balancing. A sand washing apparatus which looks cumbersome for the purpose for which it is intended is described and illustrated, almost a page being devoted to it, while the magnetic separator largely used throughout the metallurgical industries, is passed over in three lines. A common fault throughout the book is also evident here, where patented appliances for coal washing are described and nothing is said of the *spitzkästen*, so widely used in coal washers in this country. Chapter XII is devoted to the purification of gases. The Mumfort and Moodie separator described here, we would hardly consider, however, as a dust collector, but rather a separator for classifying ground material. The counterpart of this machine, the Pfeiffer, is largely used in a number of industries for separating the fully ground material from the unground, after pulverizing. Chapter XIII is on evaporating, distilling and condensing. Chapter XIV is on drying appliances and describes most of the forms of dryers. It is rather weak, however, in not mentioning a number of excellent indirect current dryers. Chapter XV is on the measurement of temperature; the book, however, contains nothing, except a description of one packing scale, on apparatus for measuring either volume or weight in chemical factories. The book concludes with Guttman's paper before the Society of Chemical Industry on "The Works Chemist as an Engineer."

In spite of its many faults we believe that Dr. Nagel's book will prove acceptable to those who are interested in chemical machinery because of the want for a better, and as we have stated, the subject is such a large one, that it is a very hard matter to cover it in brief space, and equally hard for one man to cover so much machinery, used for such widely divergent purposes.

Fractionation of crude petroleum by capillary diffusion was suggested by David T. Day by the refining of black vasline by filtering it through warm, dry, fuller's earth. Experiments conducted by the U. S. Geological Survey showed that when petroleum is allowed to rise in a tube packed with fuller's earth there is a decided fractionation of the oil, the fraction at the top of the tube being of lower specific gravity than that at the bottom. When water is added to fuller's earth which contains petroleum, the oil which is displaced first differs in specific gravity from that which is displaced afterward, when more water is added. When petroleum is allowed to rise in a tube packed with fuller's earth the paraffine hydrocarbons tend to collect in the lightest fraction at the top of the tube and the unsaturated hydrocarbons at the bottom. When oil is mixed with fuller's earth and then displaced with water, about one-third of the oil remains in the earth.

CORRESPONDENCE.

We have a large amount of timbering in the shape of ties and poles and we find renewals of these are necessary very frequently. It has been suggested that we use preservatives on our timber. Can you refer us to any literature on the subject, and give us an idea of what such wood preserving will cost, and an estimate of how much of a plant we will need?

ELECTRIC RAILWAY.

It is probable that the process which will suit you best is what is known as the "open-tank" method of preserving timber. You will find two very good papers on this subject in recent issues of *The Engineering News*; one by Mr. Howard F. Weiss was read at the convention of the American Street and Interurban Railway Engineering Association, and appeared in the issue of October 22d; the other on wood preservation by the open-tank process is by Mr. Ernest F. Hartman, and appeared in the issue of December 31st.

A plant such as you desire for this purpose will probably cost between \$8,000 and \$10,000. The actual cost of treatment seems to vary considerably at different points, but runs between \$5 and \$7 per thousand feet.

Can you inform me of some chemical which we can employ to prevent the freezing of our automatic sprinklers?

SPRINKLER.

Ordinarily, as you probably know, sprinklers are filled with compressed air. If you desire, however, to have your sprinkler full of water, the addition of calcium chloride to this latter will prevent its freezing. One thing must be considered, however, in this connection, namely, that solutions of calcium chloride have a high co-efficient of expansion, and that the check valve on the sprinkler system prevents this expansion finding relief back into the water main. It is probable that the expansion might be sufficient to burst the sprinkler and flood the factory with water. To guard against this an air chamber should be provided in the highest point of the building. This latter can be made of a large piece of pipe and should be so capped that it is airtight. The air being elastic the expansion of the calcium chloride solution will work against this and consequently can do no damage.

Can you give me any information as to the uses of sulphuric acid and the relative amounts of this chemical which are employed in various industries?

ACID.

The following table, which is taken from the census of the United States for 1905, gives the percentages of sulphuric acid used in the various industries:

	Per cent.
Fertilizer manufacture	51.5
Petroleum refining	11.7
Pickling iron and steel	8.1
Alum manufacture	4.6

Mixed acids manufacture	4.1
Textile industry	3.2
Muriatic acid manufacture	3.1
Nitric acid manufacture	3.0
Acetic acid manufacture	1.2
Ammonium sulphate manufacture	0.9
Explosives manufacture	0.9
Blue vitriol manufacture	0.7
Miscellaneous uses	6.8

It will be seen that more than one-half is used in the manufacture of fertilizer. These works, however, nearly all of them have their own acid plants. It is barely possible, however, that the new acid plants which are being erected by the Ducktown Sulphur, Copper and Iron Co. and the Tennessee Copper Co. will supply a great many fertilizer manufacturers with the acid which they need. This is indicated by the fact that the fertilizer manufacturers in Tennessee seem to be holding back from making contracts for pyrites with a view to the possibility that the smelters, manufacturing the acid as they do from their waste gases, will be able to furnish it at a cost lower than that of manufacture on the premises from pyrites.

INDUSTRIAL AND PLANT NEWS.

Beer. It is reported that J. B. Dunphy, a stockholder in the People's Brewing Co., of Duluth, is forming a stock company to erect a brewery costing \$500,000 in Southern Minnesota.

Coke. The H. C. Frick Coke Co., the coking company of the United States Steel Corporation, has decided to abandon work on their new bee-hive coke ovens in Pennsylvania, which were estimated to cost \$3,000,000, and in their stead will construct a by-product coke plant at Gary, Ind. The plant is to supply Chicago and many other towns in Northern Illinois and Indiana with gas. The by-product plant will replace about 1,700 bee-hive ovens, located at Filbert, Ralph and Sarah, Pa.

Coke. It is reported that the merging of the Republic Coke Co. and the River Coal Co. has been formed under the name of the Republic-Connellsville Coke Co. The headquarters of the new concern are to be in Pittsburg, Pa., and it is understood that additional coking plants will be erected by the company. The capitalization of the plant is \$2,500,000.

Foundry. The Frontier Iron Works, Walter F. Semon, Pres., 2 Auburn Ave., Buffalo, N. Y., will build a foundry in the latter city along the line of the New York Central railroad.

Gas Mantles. The General Gas Mantle Co. will build a 2-story and basement factory, 50x80 ft. at Fourth and Jefferson Sts., Camden, N. J., for the manufacture of incandescent gas mantles. The cost will be about \$10,000.

Iron. It is reported that the Lake Superior Corporation will arrange as soon as the financial plans can be completed for the erection at the Sault of a large blast furnace in addition to the two now in use; one or more open-hearth steel furnaces and a rolling mill to make structural steel, plates and merchant steel.

Oil. The Louisiana Oil Co., Col. G. W. Hardy, Mgr., Shreveport, La., has purchased 500 acres of land near Shreveport, and will erect a plant for separating fuel oil from the crude product from the Caddo field.

Paper. The Southern Cotton Stalk, Pulp & Paper Co., W. E. McMillen, Pres., Chandler Bldg., Atlanta, Ga., will build a mill as soon as a suitable location can be deter-

mined, which will manufacture paper out of cotton stalks. The estimated cost of the plant is \$75,000.

Paper. The Lawless Paper Co., 89 St. Paul St., Rochester, N. Y., will build a paper mill at Penfield, N. Y., to cost \$50,000.

Paper. The Marathon Paper Mills Co., mentioned in our last issue, as having been incorporated by Wausau, Wis., capitalists, will build a \$50,000 mill with a capacity of 50 tons per day near Wausau. A dam 450 ft. in length will be built across the Wisconsin River at Rothschilds, 5 miles south of Wausau, to furnish power for the plant and other industries in this section.

Shoe Blacking. The Boston Blacking Co., 96 Beverly St., Boston, Mass., will build a 5-story brick fireproof factory, 40x83 ft., to cost about \$30,000, for the manufacture of shoe blacking.

Soap. It is reported that the Proctor-Gamble Co., of Cincinnati, Ohio, will erect a soap factory at Macon, Ga.

Steel. It is understood that the James A. Moore Investment Co. have let contract upon which work is to be begun immediately, for the construction of a complete steel plant, to be installed at Irondale, near Port Townsend, Washington.

Steel. The Midland Steel Co., H. C. Fownes, Pres., is reported to be contemplating the erection of an open-hearth steel plant in the near future.

Steel. The Inter-Ocean Steel Co., W. L. Jacoby, Pres., it is reported will erect in Chicago Heights, Ill., a plant for the manufacture of steel rims. It was designed by Julian Kennedy, Bessemer Bldg., Pittsburg, Pa., the well known blast furnace engineer.

RECENT INVENTIONS

The following patents relating to applied chemistry and metallurgy are reported for The Chemical Engineer by C. L. Parker, attorney in chemical patent causes, 908 G street, Washington, D. C.

907,007. *Safety-Explosive.* Norbert Ceipek, Vienna, Austria-Hungary. December 15, 1908.

The explosive consists of a mixture of ammonium nitrate with carbonized turmeric powder.

907,180. *Composition for Purifying Air.* Herbert Ryder and Lyndon C. Wilson, Neward-on-Trent, England. December 22, 1908.

The composition is composed of glycerine, calcium carbonate and potassium meta-bisulphite.

907,758. *Finish-Reviver.* Carleton Ellis, Larchmont, N. Y. December 29, 1908.

The composition consists of petroleum oil, water, alcohol and soluble oil, said oil and water being differently and vividly colored.

908,051. *Manufacture of Acetylene Tetrachloride.* Julius Voigt, Schwanheim-on-the-Main, Germany. December 29, 1908.

The process consists in causing acetylene and chlorine gases to unite while contained in a body of granular non-catalytic material.

908,126. *Art of Method Treating and Utilizing Chlorine Gas.* Edward C. Paramore, Philadelphia, Pa. December 29, 1908.

The method comprises first generating chlorine gas, then washing it with acid to remove moisture and impurities, next cooling it, then heating it to a high degree to prepare it for electrification, then passing it into an electrifying chamber, then electrifying the gas in said chamber by electric influences, passing through the dielectric walls of the chamber, and finally liquefying the gas.

908,130. *Method of Producing Silicon.* Henry N. Potter, New Rochelle, N. Y. December 29, 1908.

The process consists in reacting upon silicon carbide by means of silicon dioxide under fluid silicon.

- 908,132. *Printing Ink*. Henry N. Potter, New York, N. Y. December 29, 1908.

The ink is composed of a drying varnishing coloring matter and silicon monoxide.

- 908,171. *Process of Oxidizing Camphor for the Making of Camphor*. Albert Verley, Paris, and Edouard Urbain and Andre Feige, Gentilly, France. December 29, 1908.

The process consists in producing a solution of camphor from camphor by dissolving sodium bichromate in water and adding sulphuric acid; dissolving camphor in a non-oxidizable solvent; diluting the first solution with water; adding the camphor solution; agitating the mass in the cold and separating the camphor.

- 908,357. *Method of Producing Silicon Carbide*. Frank J. Tone, Niagara Falls, N. Y. December 29, 1908.

The process consists in embedding a resistance conductor in a charge of silicious and carbonaceous material, initially heating the charge by combustion and then passing current through the resistance conductor sufficient to produce silicon carbide.

- 908,603—*Method of Treating Electrolytic Slimes for the Recovery of Metals Therefrom*. Alexander J. McNab, January 5, 1909.

The method consists in treating electrolytic slimes with alkali-sulphide, separating from the residue the solution thus formed, separating a metal from the solution by electrolysis, and roasting the residue and recovering metals therefrom.

- 908,696—*Method of Making Sulphuric Acid*. Ingo Petersen. Jan. 5, 1909.

The method consists in generating sulphurous acid gases, passing said gases in contact with two supplies of nitrous vitriol of different strength in two separate steps, thereby forming two different supplies of Glover acid, submitting the escaping gases to lead chamber action, treating and absorbing the escaping gases which then contain oxides of nitrogen, in two separate steps with the two previously obtained Glover acids, thereby producing two separate supplies of nitrous vitriol and separately treating a new supply of sulphurous acid gases with each of said two supplies of nitrous vitriol.

- 908,925—*Manufacture of Rubber*. Meyer Wilderman. January 5, 1909.

A process consists in freeing the rubber from mechanical and volatile impurities and washing and drying under vacuum, and treating with a mixture of solvents, one of which when alone is a solvent of all the constituents of the rubber, while another is only a solvent of resins.

- 909,169—*Waterproofing Paint for Portland Cement Structures*. Thomas A. Edison. January 12, 1909.

The method of making the paint consists in dissolving the petroleum residue known as "B. S." in suitable solvent and removing the insoluble portions thereof.

- 909,171—*Magnesia Cement*. Carleton Ellis, January 12, 1909.

A dry substantially non-hygroscopic powder, comprising oxide of magnesium and saline bodies capable of gradually reacting in the simultaneous presence of water, and said oxide to form chloride of magnesium, whereby setting qualities are conferred upon the composition, due to the formation of oxychloride of magnesium.

- 909,257—*Method of Producing Cellulose Threads*. Edmund Thiele. January 12, 1909.

The method consists in producing cellulose threads, by permitting a concentrated solution of cellulose in ammoniac copper to issue from comparatively wide apertures into a slowly acting precipitation bath, drawing out the threads so formed in this bath, and subsequently treating them with a boiling caustic lye.

- 909,271—*Sulphur Color and Process of Making Same*. Emile T. Bondsman. January 12, 1909.

The process consists in heating a mixture of sugar, metanitrilanil and a sulphuring agent.

- 909,343—*Manufacture of Tanning Extracts*. Donald Stewart. January 12, 1909.

The process consists in manufacturing tanning extracts and liquors by adding waste sulphite liquor, whose ash contains not more than 6 per cent of iron calculated as FeO to tannin-containing material.

- 909,536—*Composition of Matter for Generating Hydrogen*. George F. Brindley. January 12, 1909.

The composition of matter contains an alkali metal, an inert substance and an agent for temporarily preventing the oxidation of the alkali metal.

- 909,546—*Smokeless Gunpowder*. Conrad P. H. Claessen. January 12, 1909.

The gunpowder consists of a mixture of nitrocellulose and nitroglycerine with about 5 per cent diethyldiphenyl-carbamide.

- 909,667—*Process of Obtaining Nickel from Silicious Ores*. Edgar F. Price. January 12, 1909.

The process consists in producing ferro-nickel by smelting a charge containing a silicious ore of nickel and iron and carbon by means of an electrically heated resistance conductor withdrawing the slag and product from the furnace and supplying the charge mixture as required.

- 910,049—*Composition for Removing Finish*. Carleton Ellis. January 19, 1909.

The remover comprises approximately one gallon of turpentine with which one-half to one pound of aluminum resinate has been incorporated, combined with about 10 per cent of acetone.

- 910,121—*Process of and Apparatus for Making Cement Clinker*. Carleton Ellis. January 19, 1909.

The process comprises the clinkering of calcined cement material by a flame burning with regeneratively heated air, diversion of a portion of the flame gases from such flame into regenerative heaters for air for such flame and calcination of cement material by the residue of said flame gases.

- 910,146—*Process of Purifying Pine Oil, Pine Tar Oil, and Wood Tar Oil*. Otto P. Pellnitz. January 19, 1909.

The process consists in purifying pine oil, pine tar oil, and wood tar oil by heating the same with zinc dust for two hours in a closed receptacle provided with a condenser up to about 100 degrees C., by cooling thereafter the oil by drawing off the same into a washing apparatus provided with a stirring gear, by washing it with water and by distilling the oil.

- 910,365—*Blasting Powder*. Wilhelm Eberle. January 19, 1909.

The powder consists of saltpeter, sulphur, carbon, and horse dung in the form of dust, in the proportions of twelve to three to one to one parts by weight respectively.

- 910,394—*Process for the Reduction of Refractory Oxide*. Karl A. Kuhnle. January 19, 1909.

The process consists in mixing throughout the mass peroxides of metals easily giving off their oxygen and other than those of the elements to be reduced, with the aluminum and oxygen containing compounds of said elements, and then igniting the mixture.

- 910,440—*Process for Distilling Glycerin*. Frank J. Wood. January 19, 1909.

The process consists in supplying to the still a portion of the steam from which the glycerin vapors of a previous distillation have been condensed, and adding live steam to the steam supply.

- 910,520—*Method of Manufacturing Solutions of Caoutchouc*. Emil Fischer. January 26, 1909.

A method consists in treating raw caoutchouc with symmetrical dichloroethylene.

- 910,521—*Process for the Production of Soluble Starch*. Ferdinand Fritsche. January 26, 1909.

The process consists in mixing common starch with a perborate and heating said mixture.

The Chemical Engineer

PUBLISHED BY

The Chemical Engineer Publishing Co., 355 Dearborn St., Chicago

Vol. IX.

APRIL 1909.

No 4.

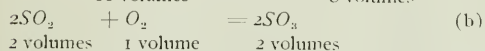
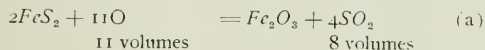
SOME FORMULAE AND TABLES FOR GAS CALCULATIONS IN THE CONTACT PROCESS FOR SULPHURIC ACID.

By ALFRED J. LOTKA.

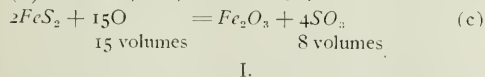
As a basis for calculations in connection with the manufacture of sulphuric acid by the contact process it is often convenient to have at hand formulæ and tables by means of which the composition of a typical pyrites burner gas at any stage in the process can be readily calculated.

Such formulæ and tables are given below, together with the method of deducing the same, and a few examples showing the manner of applying them.

In the developments given under I and III below, it is assumed that the (pyrites) gases in a contact system may be regarded as the product of the two reactions:



The reaction (b), which we will speak of as the "conversion," may take place simultaneously with (a), or may follow thereon. In either case the SO_3 formed may be regarded as the result of reactions (a) and (b) combined, i. e., of a reaction:



I.

For the purposes of our first calculation it is immaterial whether the conversion takes place simultaneously with the burning of the ore, or subsequently.

Let the total conversion at a given stage in the process be $c\%$ of the sulphur burnt, and let the resulting gas contain $p\%$ SO_2 : For every 100 volumes of gas,

there must therefore have been produced $p \frac{c}{100 - c}$ volumes of SO_2 . Some of this may have been eliminated. Let p' be the percentage of SO_3 actually remaining in the gas, x the percentage of O_2 and y that of N_2 .

Consider 100 volumes of the gas, containing

SO_2 p volumes
 SO_3 p' volumes
 O_2 x volumes
 N_2 y volumes

Now the volume of air which was used to produce these 100 volumes contained, in addition to y volumes of N_2 and x volumes of O_2 , a further quantity of O_2 , viz., that which has been abstracted in the formation of (1) the p volumes of SO_2 and (2) the $p \frac{c}{100 - c}$ volumes of SO_3 .

According to equation (a) the volume of (1) is $\frac{11}{8}$ of the SO_2 formed, according to reaction (b) the volume of (2) is $\frac{15}{8}$ of the SO_3 formed.

Hence the air used to produce 100 volumes of the gas contained a volume of O_2 equal to $x + \frac{11}{8}p + \frac{15}{8}p \frac{c}{100 - c}$ and a volume of N_2 equal to y .

But the ratio of O_2 to N_2 in air is 21:79.

TABLE I.

	MULTIPLIES OF			
	1.296	.296	1.481	
1	1.296	.296	1.481	1
2	2.592	.592	2.962	2
3	3.888	.888	4.443	3
4	5.184	1.184	5.924	4
5	6.480	1.480	7.405	5
6	7.776	1.776	8.886	6
7	9.072	2.072	10.367	7
8	10.368	2.368	11.848	8
9	11.664	2.664	13.329	9
10	12.960	2.960	14.810	10

Hence we have:

$$x + \frac{11}{8}p + \frac{15}{8}p \frac{c}{100 - c} = \frac{21}{79} \quad (1)$$

On the other hand, obviously

$$x + y + p + p' = 100 \quad (2)$$

Putting, for convenience $\frac{c}{100 - c} = R_c$ and solving equations (1) and (2) in the usual manner, we have:

$$x = 21 - p(1.296 + 1.481 R_c) - .21p' \quad (3)$$

$$y = 79 + p(.296 + 1.481 R_c) - .79p' \quad (4)$$

If $p' = 0$, as for example, in purified burner gas, formulæ (3) and (4) take the simple form:

$$x = 21 - p(1.296 + 1.481 R_c) \quad (5)$$

$$y = 79 + p(.296 + 1.481 R_c) \quad (6)$$

The use of these formulæ, in conjunction with tables I and II, is best shown by an example:

Example 1.

What is the composition of a 7.5% purified pyrites burner gas, if 5% conversion takes place in the burners?

From table I we read:

$$\begin{aligned} 7 \times 1.206 &= 9.07 \\ .5 \times 1.206 &= .65 \end{aligned}$$

$$7.5 \times 1.206 = 9.72$$

From table II we read:

$$\begin{aligned} 7 \times 1.481 R_5 &= .55 \\ .5 \times 1.481 R_5 &= .04 \end{aligned}$$

.59

$$\text{Hence by (5) } x = 21 - (9.72 + .59) = 10.69$$

y can be found by formula (6), or more simply by difference, since $x + y + p = 100$.

Thus:

$$\begin{aligned} p &= 7.50 \\ x &= 10.69 \\ y &= 81.81 \end{aligned}$$

100.00

TABLE II.

c	R_c	1 481 $p R_c$										c
		$p=1$	$p=2$	$p=3$	$p=4$	$p=5$	$p=6$	$p=7$	$p=8$	$p=9$	$p=10$	
0	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0
1	0101	0150	0299	0449	0598	0748	0898	1047	1197	1346	1496	1
2	0204	0302	0605	0907	1209	1511	1814	2116	2418	2721	3023	2
3	0309	0458	0916	1374	1832	2290	2748	3207	3665	4123	4581	3
4	0417	0617	1234	1851	2468	3085	3703	4320	4937	5554	6171	4
5	0526	0780	1559	2338	3118	3897	4677	5456	6236	7015	7795	5
6	0638	0945	1891	2836	3781	4727	5672	6617	7562	8508	9453	6
7	0753	1115	2229	3344	4459	5573	6688	7802	8918	1 0032	1 1147	7
8	0870	1288	2576	3864	5152	6439	7727	9015	1 0303	1 1591	1 2879	8
9	0989	1465	2929	4394	5859	7323	8788	1 0253	1 1718	1 3182	1 4647	9
10	1111	1646	3291	4937	6582	8227	9873	1 1518	1 3164	1 4810	1 6455	10

II.

Let a gas of composition

SO_2 , $p\%$

O_2 , $x\%$

N_2 , $y\%$

undergo $c\%$ conversion. To find its composition

(a) after conversion.

(b) after conversion followed by elimination of the SO_3 formed.

(a) Consider 100 volumes of the gas. This after $c\%$ conversion will give:

SO_3 $p \frac{c}{100}$ volumes.

SO_2 $p - p \frac{c}{100} = p \frac{(100-c)}{100}$ volumes.

O_2 $x - \frac{pc}{200} = \frac{100x - .5pc}{100}$ volumes.

N_2 y volumes.

Hence the total volume after conversion will be

$$(x + y + p) - \frac{pc}{200} = 100 - .005 pc.$$

and therefore the percentage of SO_2 , SO_3 , O_2 and N_2 in the converted gas will be:

$$SO_2 \quad p_1 = \frac{p(100-c)}{100-.005pc} \quad (7)$$

$$SO_3 \quad p_1' = \frac{pc}{100-.005pc} \quad (8)$$

$$O_2 \quad x_1 = \frac{100x - .5pc}{100-.005pc} \quad (9)$$

$$N_2 \quad y_1 = \frac{100y}{100-.005pc} \quad (10)$$

If the SO_3 is completely eliminated the total volume will be further diminished by $\frac{pc}{100}$ volumes, leaving

$100 - .015 pc$ volumes. The other constituents are unchanged. Their percentages will therefore now be:

$$SO_2 \quad p_2 = \frac{p(100-c)}{100-.015pc} \quad (11)$$

$$O_2 \quad x_2 = \frac{100x - .5pc}{100-.015pc} \quad (12)$$

$$N_2 \quad y_2 = \frac{100y}{100-.015pc} \quad (13)$$

We may solve (11) for c :

$$c = 100 \frac{p - p_2}{p} \frac{1}{1 - .015p_2} \quad (14)$$

If p_2 is small, we can put $1 - .015p_2 = 1 + .015p_2$

Then, $c = 100 \frac{p - p_2}{p} (1 + .015p_2)$ (15)

We can write (15) in the form:

$$c = 100 \left(\left(1 - \frac{p_2}{p}\right) (1 + .015p_2) \right)$$

If $\frac{p_2}{p}$ is small, so that we can neglect the term in p_2^2 , this reduces down to

$$c = 100 \frac{(p - p_2)}{p} + 1.5p_2 \quad (16)$$

Lastly, if p_2 is sufficiently small, this may be further simplified to

$$c = 100 \frac{p - p_2}{p} \quad (17)$$

Formula (14) is exact. Formulæ (15), (16) and (17) are approximate: (15) will give c correct to within 1 in the second place of decimals if $p_2 \leq .66$; (16) will give c correct to within 1 in the second place if $p_2 \leq .22$ and $p \leq 7.5$; (17) will give c correct to within 1 in the units figure, if $p_2 \leq .66$.

Example 2.

The burner gas of Example 1 having the composition

SO_2	7.50%
O_2	10.69%
N_2	81.81%
100.00%	

undergoes 98% conversion. What will be the composition (a) of the converted gas, and (b) of the exit after absorption?

(a.) By (7) we have for the SO_2 :

$$p_1 = \frac{7.5(100 - 98)}{100 - (.005 \times 7.5 \times 98)} = .16\%$$

for the SO_3 by (8)

$$p_1' = \frac{7.5 \times 98}{100 - (.005 \times 7.5 \times 98)} = 7.63\%$$

for the O_2 by (9)

$$x_1 = \frac{(100 \times 10.69) - (.5 \times 7.5 \times 98)}{100 - (.005 \times 7.5 \times 98)} = 7.28\%$$

for the N_2 by (10)

$$y_1 = \frac{100 \times 81.81}{100 - (.005 \times 7.5 \times 98)} = \frac{84.93\%}{100.00}$$

(b.) For the SO_2 we have by (11)

$$p_2 = \frac{7.5(100 - 98)}{100 - (.015 \times 7.5 \times 98)} = 17\%$$

for the O_2 by (12)

$$x_2 = \frac{(100 \times 10.69) - (.5 \times 7.5 \times 98)}{100 - (.015 \times 7.5 \times 98)} = 7.88\%$$

for the N_2 by (13)

$$y_2 = \frac{100 \times 81.81}{100 - (.015 \times 7.5 \times 98)} = \frac{91.95\%}{100.00}$$

Example 3.

The gas at the inlet of a converter analyses 7.5 SO_2 , at the outlet (after eliminating the SO_3) .24% SO_2 . What is the per cent conversion in the converter?

Formula (14) gives the exact value. $c = 97.151$

Formula (15) gives the approximate value. $c = 97.149$

Formula (16) gives the approximate value. $c = 97.161$

Formula (17) gives the approximate value. $c = 96.801$

III.

Lastly, we may combine formulæ (5) and (12), to give us directly the relation between x_2 , the percentage of O_2 in the exit, p_0 , the percentage of SO_2 in the gases from the burners, c_0 the per cent conversion in the burners, and c_1 the per cent conversion in the system.

Thus, if x_0 = percentage of O_2 in the gases from the burners, (12) gives us:

$$x_2 = \frac{100 x_0 - .5 p c_1}{100 - .015 p c_1} \quad (18)$$

while (5) gives

$$x_0 = 21 - p_0 (1.296 + 1.481 R_{c_0}) \quad (19)$$

Substituting for x_0 in (18) from (19), and dividing numerator and denominator by 100.

$$x_2 = \frac{21 - p_0 (1.296 + 1.481 R_{c_0} + .005 c_1)}{1 - .00015 p_0 c_1} \quad (20)$$

or solving for p_0 :

$$p_0 = \frac{21 - x_2}{1.296 + 1.481 R_{c_0} + c_1 (.005 - .00015 x_2)} \quad (21)$$

Example 4.

What must be the composition of a burner gas if the exit after 5% conversion in the burners, and 98% conversion in the system, is to contain 6% O_2 ?

By (21) we have:

$$p_0 = \frac{21 - 6}{(1.296 + 1.481 R_5) + 98 (.005 - .00015 \times 6)}$$

The term 1.481 R_5 we can read off Table II.

We thus find:

$$\begin{aligned} p_0 &= 8.45\% \\ \text{Hence by (5) and (6)} \\ x_0 &= 9.39\% \\ y_0 &= 82.16\% \\ &= 100.03\% \end{aligned}$$

THE MANUFACTURE OF SODA ASH BY THE AMMONIA PROCESS.¹

By WM. MASON.

On the 28th of June, 1838, Dyar and Hemming published for the first time the principles of the ammonia soda process. Their method consisted of adding ammonium carbonate in solid form, to a saturated solution of sodium chloride; later they stated that ammonium bicarbonate would be more advantageous. In 1884, a factory was erected at Middlesbrough, which was to use a method, on which Schloesing had a patent, and which resembled Dyar and Hemming's process. Ammonium bicarbonate was first made in the form of crystals and then mixed with a solution of sodium chloride. In 1854, Schloesing and Roland obtained a patent for another process, which was described and illustrated to the minutest details in the specifications. The process consisted of allowing carbon dioxide gas to pass through an ammoniacal solution of sodium chloride; this method is still used in the Solvay process. Schloesing and Roland erected a factory and produced over 300 tons of soda in two years, but finally failed. It seems surprising that, though they had given such an accurate description of their process, they failed to carry it out. That they should have had success was the opinion of Solvay.

In 1863, Solvay obtained a patent for a plant for the above method and erected, a few years later, a factory in Couillet, Belgium, where he produced 179 tons of calcined soda in the first year. He was the first who made a financial success, which had not been done in the history of the chemical industry with Schloesing and Roland's method.

Hundreds of patents have been granted since that time for processes and machinery, and numerous companies were formed. Some of these corporations obtained sufficient capital by promising high profits to investors, built large factories, operated them one or more years, but finally failed to make a financial success.

It has often been found, that during the carbonation, a certain amount of sodium bicarbonate remains dissolved in the salt lye residues, and is therefore lost. Solvay proposed, in one of his patents, to introduce salt into the carbonator for the recovery of this bicarbonate. But the ordinary salt which is used in chemical factories contains up to 0.8% impurities, which causes an increase in the percentage of the insoluble matter in the finished calcined soda. In 1878, Dr. L. Mond obtained a patent on a process for the purification of salt solutions which consisted in adding com-

¹ Translated from *Chemiker-Zeitung*, Vol. XXXIII, No. 3.

pounds similar to those used for the softening of water. This process was practiced for a period and then abandoned. Later ordinary table salt was used. It remained to be proved, however, whether the salt which was added in this manner was decomposed, or whether it was necessary to prevent the loss of bicarbonate in the liquors. For this purpose about 500 kgrm. of salt were required for each ton of calcined soda produced. This salt contained 10% moisture, which effected a dilution of the liquors; which was later increased to 50%, on account of the large quantities of water, which were required for leaching the salt from the bicarbonate. The water carried along dissolved bicarbonate, and increased the amount of solution, which had to be carried through the ammonia retort, making the cost considerably higher. Below are given a few analyses of residual lyes: (I) from a Solvay tower filled with salt; (II) from a plant working without adding salt; and (III) from liquors from the Solvay towers after it had been found out that a salt addition was not required in order to obtain a residual lye from the carbonator, which would contain little or no dissolved bicarbonate.

I. SOLVAY-TOWER-LYE WITH SALT ADDITION.

% alkali (calculated as NH_3)	1.49	1.19	1.61	1.56	2.22	1.93
Ammonium chloride	10.53	17.12	16.42	16.37	14.29	15.62
Sodium chloride	13.11	12.98	12.29	13.44	14.98	12.37

II. CARBONATOR SOLUTION WITHOUT SALT ADDITION.

% alkali (calculated as NH_3)	1.65	1.87	1.56	1.63	1.73
Ammonium chloride	18.88	17.97	18.08	17.33	18.08
Sodium chloride	6.88	7.28	7.74	8.00	8.23

III. SOLVAY-TOWER-LYE WITHOUT SALT ADDITION.

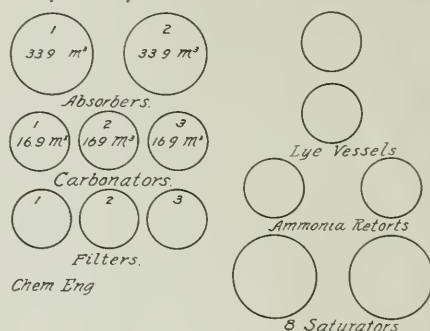
% alkali (calculated as NH_3)	2.02
Ammonium chloride	17.22
Sodium chloride	8.45

The analyses in II and III indicate distinctly that much better results were obtained in these cases than with the addition of salt, as for a certain amount of ammonium chloride formed the equivalent amount of sodium carbonate is precipitated, as sodium bicarbonate. It may also be stated that the plant which obtained the above residual lyes ought to have worked successfully if the other operations were carried out correctly.

Although the ammonia-soda process is so simple (entirely contrary to the LeBlanc process), that anyone who has some practical chemical knowledge is able to manufacture sodium carbonate by this method, yet it requires intense care to attain financial success by its use.

Although the process originated in England, it was not used there until 1874. In this year a factory was erected in Northwich, and in the following year one at Sandbach. In 1874, Solvay produced about 4,678 tons and it is probable that both mentioned plants could

have produced about the same quantity. They are described in detail in the specifications of English patents Nos. 999 and 1,904, of the year 1876. The works at Sandbach consisted of a number of lime kilns, four ammonia retorts with heaters and absorbers, five carbonators, four dryers and a number of tanks. The plant yielded a large profit, but it had to be shut down frequently for repairs on account of the complicated apparatus—especially the ammonia retorts, where the connecting pipes got clogged up often and the valves leaked frequently. The lime which was used unslacked, was, also, very often poorly burned. For these reasons the plant was only two-thirds of the total time working, but notwithstanding all these difficulties the plant was operated until 1881. At that time Dr. Ludwig Mond introduced in his plant an upright ammonia retort, for which he obtained a patent, in 1883. This retort proved to be so successful that the daily yield was increased more than one-third, i. e., from 13 tons to 21 tons, without making it necessary to enlarge any other part of the plant. The upright retort made a continuous process possible, and only one day in about six weeks was it necessary



to shut the plant down. The works were enlarged to double the former size and were operated very successfully for many years. A vertical still was used long before this time for the distillation of ammonia liquors, and it is therefore very surprising that it was not used first, as it is much cheaper in construction. Solvay describes such a retort in the specification of his patents, in 1876. The carbonator for which Solvay obtained a patent in 1872 is the only valuable and ingenious invention which was made in connection with this process. As the patent of the Solvay carbonator, which proved so successful, expired in 1886, another factory was erected in the same year at Runcorn, which had more simple apparatus than Solvay's; indeed, it consisted of about 30 large, cylindrical vessels, made from sheet iron. The above diagram gives an idea of the working of the process.

The ammonia gases passed from the retorts, without being cooled, into the so-called saturators, which contained salt brine and into which salt in solid form was also introduced by means of a basket, which passed through the saturators, so that the lye could be formed and at the same time saturated with ammonia, in one

operation. The ammoniacal salt lye so formed was similar to the one obtained by the Solvay process. The great disadvantage of this process consisted in the fact that a large quantity of salt settled in the saturators, sometimes 10½ feet high, so that a determination of the ammonia contents was very difficult, a circumstance which is of great importance in this process. The retorts in this part of the plant generated sometimes 279 kgrms. of ammonia per hour. From the saturators the ammoniacal lye, after cooling and settling, passed into two so-called absorbers, one of which was always filled with this liquor, while the other was operated in connection with the carbonation plant. This carbonation plant consisted of three vessels, each one containing about 17 cbm. ammoniacal lye. The carbon dioxide from the lime kiln, after washing and cooling, passed with an initial pressure of three atmospheres through these carbonators, then through an absorber, then through a vessel containing salt lye, and finally, through a vessel containing acid. It must be emphasized here, that the solution, which contains the largest quantity of free ammonia, was brought into contact with the weakest carbon dioxide stream. The figures below show the ammonia contents of these gases as they pass from vessel to vessel, in grains per cubic foot: From carbonator 1 to carbonator 2, 2.89; carbonator 2 to carbonator 3, 3.63; carbonator 3 to absorber, 8.96; absorber to lye vessel, 21.71; lye vessel to acid vessel, 0.708. The Solvay tower is arranged and operated in such a way that this ammonia is retained in the tower. The lye vessel contained sometimes a considerable amount of ammonia, 3.6% or more. Each day (24 hours) five carbonators were worked up and a yield of ten tons of calcined soda was obtained. The washing of the bicarbonate caused a loss of 20%.

Analyses of the residual lyes from the above carbonators have already been given (No. 2). The figures below show the way these carbonators worked at different times, and the percentage of the ammonia which is transformed into ammonium chloride.

CARBONATOR 1.

Time,	Per cent alkali figured as NH_3 .
6	6.5
7	5.7
9	4.7
11	4.0
1	2.9
3	2.3
5	1.9

CARBONATOR 2.

Time,	Per cent alkali figured as NH_3 .
12	6.0
1	5.2
3	3.7
5	2.5
7	1.8
9	1.4

Per cent alkali of the lye in the carbonator after the above was worked up:

Carbonator 3	2.3
Carbonator 1	4.6

CARBONATOR 3.

Time.	Per cent alkali figured as NH_3 .
11	6.1
12	5.6
1	5.1
2	4.7
3	4.4
4	3.6
5	3.2
7	2.5
9	2.0
11	1.8
1	1.6
2	1.6
3	1.6

Per cent alkali of the lye in the carbonator after the above was worked up:

Carbonator 2	3.6
Carbonator 3	6.1

With the Solvay towers, the 17 cbm. of ammoniacal lye could be worked up in less than three hours, in proportion to the advancement of the carbonation in these carbonators, and a yield of at least 15 tons of calcined soda, instead of 10 tons, could be attained. Very likely the capacity of the plant was 24,750 kgrm. of ammonia, which was sufficient for a daily production of 35 tons of calcined soda. Sixteen tons of lime stone were burned daily. A special feature of the plant was that the solution ran from one vessel to another by gravity so that no pumps were required.

In 1889 another plant similar to the above was erected in Middlewich, but on a much larger scale. It was equipped with two ammonia retorts, which resembled in construction Mond's retort of the Solvay process, but the superheater was equipped with coils. There were also four carbonators, which resembled those used at Runcorn, and four limekilns. If practically managed this factory ought to have yielded at least 600 tons of calcined soda per week, but only 300 tons were obtained at full capacity and 200 tons at half capacity per week. The following examples will explain this:

If the plant worked full capacity and contained a quantity of ammonia equal to 55,950 kgrms. NH_3 , 104 tons of limestone were burned, 448 cbm. residual lye were distilled and 420 cbm. salt lye were used, thus 55.8 tons of calcined soda were produced in 24 hours. About 20 carbonators were required, each of which would hold 23.5 cbm. ammonia lye. If the plant worked only half capacity and contained a quantity of ammonia equal to 22,500 kgrm. NH_3 , 184.8 cbm. lye were used and 23.68 tons of calcined soda were produced; about 10 carbonators were operated.

The ammonia loss in this plant was from 3 to 15% (i. e., parts of ammonium sulphate for 100 parts of

calcined soda). Below are given a few analyses of the lye from the above carbonators:

Number	1	2	1	2	1
Number of carbonator.	1	1	2	2	3
Per cent of alkalinity					

figured as NH_3	3.06	2.92	2.51	3.43	2.72
Ammonium chloride...	13.16	13.80	14.59	12.94	15.08
Sodium chloride.....	12.22	11.50	10.74	12.58	10.51

Number	2	1	2	1	2
Number of carbonator.	3	4	4	1	1
Per cent of alkalinity					

figured as NH_3	2.92	2.95	3.02	2.72	2.95
Ammonium chloride...	14.12	13.74	13.48	14.33	13.68
Sodium chloride.....	11.40	11.91	12.32	11.04	11.99

Similar plants, working at intervals, were also erected in different parts of Germany thirty years ago, but they all failed. None of these works could compete with the Solvay process, and the price of salt could not have been reduced to \$13.80 per ton, as the costs for producing 1 ton of calcined soda amounted to more than \$19.30. A careful study of the working conditions of these plants shows clearly that it is possible to construct a plant which could compete very successfully with the Solvay process, which has reached the height of perfection. The history of the ammonia soda process shows that it has not yet received the attention which it deserves.

SOLUBLE GLASS. ITS MANUFACTURE, PROPERTIES AND USES.*

By M. LENGLEN.

The name soluble glass is given to the alkaline silicates and mixtures of the two, all other silicates being insoluble. The discovery was made by Van Helmont that sand fused with excess of alkali produced a deliquescent substance. For two centuries the compound was not made use of, and it was only in 1825 that Johann von Fuchs made it by fusing an alkaline carbonate with silica. The compound thus obtained was not deliquescent, but very soluble in water. No use was found for it at the time, probably owing to the fact that the composition of the material was uneven and unreliable.

The study of soluble glass was revived in the second half of the century. A large factory was built at Worms which produced compounds of constant composition and for determined uses. Many applications were found for soluble glass and soon we find 12 factories manufacturing it in Germany, which greatly reduced the price. Since then the methods for the preparation of soluble glass have changed but little. There are four distinct kinds of soluble glass:

1. Soluble potassium glass.
2. Soluble sodium glass.
3. Soluble double glass.
4. Soluble fixative glass.

METHODS OF MANUFACTURE.

Two methods may be used for its preparation, dry and wet.

A. Dry Method (by fusion)—This is the oldest. The raw materials are silica sand or powdered quartz, the alkaline carbonates and charcoal. The carbonates can be replaced by the sulphates, as will be seen further on. The most commonly employed proportions are:

SOLUBLE POTASSIUM GLASS.

	No. 1.	No. 2.
Quartz sand (pure).....	100 parts	45 parts
Potassium carbonate	65 parts	30 parts
Powdered charcoal	2 to 3 parts	3 parts

SOLUBLE SODIUM GLASS.

Quartz sand	100 parts
Sodium carbonate (Solvay).....	50 parts
Powdered charcoal	3 parts

OR

Powdered quartz	45 parts
Sodium carbonate (dry calcined).....	23 parts
Powdered charcoal	3 parts

SOLUBLE DOUBLE GLASS.

Sand	100 parts
Purified potassium carbonate.....	25 parts
Sodium carbonate	22 parts
Charcoal (powdered)	3 parts

OR

Powdered quartz	152 parts
Purified potassium carbonate.....	70 parts
Calcined sodium carbonate.....	52 parts
Powdered charcoal	4 parts

A double soluble glass can also be obtained by mixing the two separately prepared silicates. The addition of charcoal helps in the removal of the carbon dioxide, converting it into carbon monoxide.

The furnace originally used was a crucible furnace containing four crucibles, two on each side of the grate. This soon proved unsatisfactory and reverberatory furnaces were used instead. These were charged from above, and at one end of the hearth there was a tap hole through which the fused mass could be discharged into conical iron moulds or upon iron plates. The fusion should be done at bright red heat and this temperature continued to tranquil fusion. The fuel used was considerable—1½ kilos for every kilo of glass. By the use of the Sieman's regenerative furnace the amount of fuel was reduced to .200 kilo per kilo of product. Lately gas has been used as a source of heat. When the glass has cooled it is finely pulverized and usually dissolved for the market.

The solution is performed in iron tanks with mechanical agitation, one part of silicate to 5 or 6 of water being used. Steam heat is employed and solution is complete in from 3 to 4 hours. The solutions usually made are 31—32 Bé., 36—40 Bé. and 50 Bé. When sulphate of sodium or potassium are used in place of the carbonate, alkaline sulphides are formed which must be eliminated. This is done by the addition of CuO and PbO to the boiling solution.

A silicate of superior quality is obtained as follows: Soluble glass, cold and finely pulverized is exposed to the air for two weeks, during which time it is fre-

*Translated from the *Revue Générale de Chimie*.

quently shoveled over, to help oxidize the sulphides. It is now washed three times by decantation with cold water, which dissolves the sulphide and excess of alkali, then it is dissolved in boiling water. Sulphate of soda is used in place of the carbonate because the latter is much more expensive. This idea is due to Ordway, who used a mixture of sulphate and dried charcoal, the sulphide formed was eliminated by the addition of sodium arseniate to the process in fusion.

The charge ordinarily used and process of making soluble glass for sodium sulphate is as follows:

CHARGE.

Sand or pulverized quartz.....	100—
Sodium sulphate (dry).....	60—
Charcoal	25—

The mixture is melted on the hearth of a reverberatory furnace with direct flame. The materials of which the furnace is constructed should be of the best, owing to the destructive qualities of the sodium sulphide. The hearth is of refractory brick and the sides and top of fine sand stone. The hearth rests on a bed of sand 4 c. m. deep which rests on masonry. The space for fusion measures 3x1x0.3 meters. The sand-stone blocks which form the top are generally arranged in such a way that they form each one an independent fraction which can be replaced without disturbing the others. There are six openings in the roof for charging the furnace, which latter may amount to 2,250 kilos per charge. The fusion lasts 12 hours. The gas is produced in generators, and comes in at one end of the furnace, burning in contact with air which is admitted by draught openings on the sides. The process can be watched by a properly placed opening. When the mass is in tranquil fusion the tap hole is opened and the molten silicate is received upon a cast iron plate. It is coarsely ground and digested with water under pressure in sheet iron boilers. When solution is complete it is transferred to sheet iron sedimentation tanks, after having been treated with bleaching powder to eliminate the sulphides. When clear it is decanted and concentrated in cast iron pans at a temperature of 40° to 60° C., heated by spent gases. Considerable care must be exercised during evaporation, if it slacken there may be found a pellicle on the surface which impedes evaporation. Some authorities have even advocated concentration in vacuo in order to avoid the formation of polysilicic acid, which renders the solution turbid.

Other authorities advise the use of sodium chloride for the manufacture of sodium silicate. Ungerer mixes salt with twice its weight of fine sand and heats on the hearth of a furnace. When the mass is melted he injects steam, hydrochloric acid gas is evolved (which can be utilized) and the silicate is formed.

Proppe's process, patented in 1896, is as follows: Sand, sodium chloride and coal are placed on a second hearth heated by spent heat, upon the heated mixture is poured 60° Bé. sulphuric acid. Hydrochloric acid is liberated and collected. When it has been en-

tirely expelled the charge is raked upon the hearth nearest the grate and converted, by fusion, into soluble glass. The same author proposes to obtain chlorine as a by-product by the mutual reaction of sand, salt and nitrate of potash. Mixtures of nitrate and sand have also been proposed. Garguay, in 1896, advises the following mixture:

Sand	200 parts.
Sodium nitrate	100 parts.

A very fusible double glass can be obtained by fusing together molecular quantities of potassium nitrate, sodium nitrate and powdered quartz.

B.—Wet Method. (Liebig.)—Seventy-five parts by weight of calcined soda are dissolved in 530 parts of boiling water to which is added 40 parts of slaked lime. After boiling for some time the liquid is decanted and concentrated to density of 1.15, to this liquor 120 parts of unfusorial earth are added. This earth consists of pure and very finely divided silica. The solution is stirred and after some hours decanted from the solid impurities and evaporated to syrupy consistency. At present the operation is conducted under pressure in cast iron boilers into which superheated steam is injected.

Kuhlmann prepares soluble sodium glass by dissolving powdered flint in concentrated caustic soda solution in cast iron digesters at a pressure of 7 to 8 atmospheres. The solution is readily made and being 35° B. is ready for the market. The wet method seems to offer advantages, the necessary apparatus being less expensive, the quantity of heat less and the solution obtained of the proper strength for marketing. Nevertheless in practice it has not yet yielded the results which might be expected.

PROPERTIES AND USES OF SOLUBLE GLASS.

The properties may vary according to the nature, proportions and purity of material used in its manufacture. Soluble glass is more or less transparent and may be yellow or even reddish if iron is present. In the dry state potash glass does not noticeably change while soda glass effloresces and ends by breaking up and becomes a powder. Exposed to the air, solutions of soluble glass decompose quite rapidly, owing to carbon dioxide which precipitates sodium, sodium carbonate being formed, and it is to this that the alkalinity of solutions of soluble glass is due.

Among the substances that injure the quality of soluble glass there are two which must be carefully avoided. First are to be mentioned the sulphides of soda and potash which are often present in the raw materials or which may be formed during fusion. These sulphides affect the color of the product, especially if metallic oxide have been designedly added. Besides this, under the influence of carbon dioxide and the vapor of water present in the atmosphere, the sulphides may be decomposed and the soluble glass may fall to a powder. The same effect is observed if soluble glass, especially that containing soda, contains too great a proportion of alkali. The presence of lime

seems, on the contrary, to influence favorably the resistance of glass to atmospheric agencies and allows the incorporation of pigments or colors.

Potash soluble glass containing lime is not easily altered. There have been found at Herculaneum specimens of pottery in an excellent state of preservation which were glazed with a soluble glass. Artus analyzed the same and gives the following receipt for its preparation. Fuse together:

Sand	165 parts by weight.
Carrara marble	7 parts by weight.
Potassium carbonate.....	120 parts by weight.
Charcoal	10 parts by weight.

Solutions of the silicates have of late years found many applications. They are used to render tissues unflammable or incombustible. They were used for the first time at the theater of Munich and since then their use has grown. When applied on wood, paper, tissues, etc., it renders them incombustible, that is to say, they are destroyed but without flame, so that fire cannot spread rapidly. When soluble glass is applied the solution is thickened with some incombustible substance such as clay, chalk, calcium phosphate or powdered glass. Several layers are painted on the objects, being careful to dry each layer before again painting with the soluble glass mixture.

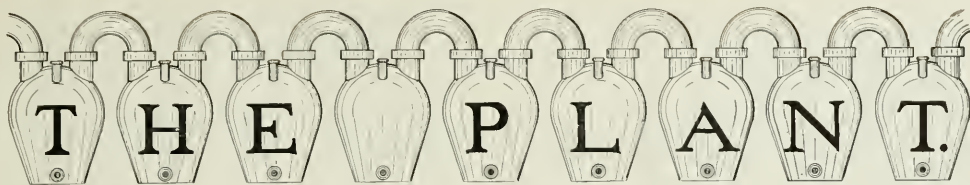
Another important application of soluble glass, more particularly potash glass, is the "silicization" of calcareous stones for their preservation. It is known that if a piece of chalk is immersed in a solution of silicate of potassium, diluted and colored, and then expose it to the air for several days, a silicious limestone hard enough to scratch marble is obtained. Under the influences of the carbon dioxide of the air silicate of lime is formed and carbonate of potassium, which produces a slight efflorescence on the surface of the stone which slowly disappears. The hardness of the compound can be increased by the use of hydrofluosilicic acid in order to form a hydrofluosilicate which is still harder. A similar reaction takes place with plaster, calcium silicate and potassium sulphate being formed. The solutions should be very dilute or the potassium sulphate will disintegrate the stone as it crystallizes. This action of potassium silicate upon limestone has been utilized by Kuhlmann who proposes to coat moldings, sculptures, architectural ornaments, etc., in order to impart to them a greater resistance to atmospheric agents, especially to frost. For this purpose it is sufficient to wash the objects and then to coat them with the dilute solution of silicate, using a brush. This method can also be applied to walls and tiles that are disintegrating. It is also used in the manufacture of artificial stone, a plastic mass of sand and silicate is molded by pressure into a paper form and dipped into a solution of calcium chloride. The silicate of lime formed causes the adhesion of the sand grains. The sodium chloride formed at the same time is eliminated by washing. A no less important property of soluble glass is that

of being a good substance with which to mend glass, porcelain, or stone.

The soap industry uses a large quantity of soluble glass, especially potash glass. Mixed with a certain proportion of glycerine, the silicate of soda gives a hard paste known as "mineral soap" and is used for scouring tissues. Large quantities are used for washing wool, also as sizing for cotton (*encollage*) and in tissue printing where it replaces albumens as a fixer of dyes and colors. The silicate of soda is used in the "*toile printe*" industry (literally painted cloth) as it has strong anti-fermentable properties. In the pure state, potassium silicate is used in the making of casts for broken limbs, etc. It has also been used in the manufacture of lead accumulators. By precipitating with dilute sulphuric acid the silicate in a gelatinous condition, this precipitate holds the excess of acid in the accumulators doing away with the liquid in part. Kuhlmann has proposed using soluble glass in place of linseed oil, etc., for mixing paint. In using such paint the surfaces upon which it is to be applied are previously "silicated" (painted over with glass solution). Carbon dioxide acts upon these paints; this is remedied by the addition of powdered lime or chalk to the ground paints. This mixture diluted with the proper quantity of potash soluble glass gives brilliant and permanent colors. On the French market may be found soluble glass colors. They are in the condition of paste and for use are diluted with twice their weight of soluble glass.

We must now speak of the process called "*Stereo-chromie*" invented by Fuchs and improved by Kaulback, which consists in the fixation of wall colors or paintings by the use of soluble glass. For this purpose a special glass called "*fixateur*" is used. It is a potash glass completely saturated with silica mixed with a soluble soda glass made by melting two parts of powdered quartz and three parts calcined sodium carbonate. The results obtained by this process have not been entirely satisfactory. Soluble glass has received other minor applications. The soluble glass industry is a flourishing one in Europe. In 1899 France produced 3,750 tons of sodium silicate and 1,400 tons of potassium silicate. Neutral soda silicate 37° to 38° Bé. is worth (at present) 7 to 8 francs per 100 kilos. The same alkaline in reaction, 45° Bé., is worth from 9 to 11 francs, while potassium silicate is worth from 15 to 18 francs.

It is stated that five kilos of turpentine oil may be obtained as a by-product in the manufacture of pulp by the sulphate process from the wood of the *Pinus Sylvestris*. This oil, however, is of a low quality owing to the presence of noxious sulphur impurities. Practically none of the sulphate pulp mills make any attempt to recover this turpentine at the present time, as, so far, no satisfactory process has been found for freeing this turpentine oil from the impurities which it contains.



APPARATUS FOR WEIGHING AND MEASURING SOLIDS, LIQUIDS AND GASES.*

Written for THE CHEMICAL ENGINEER.

(Continued from March, 1909, issue.)

For measuring cyanide solutions the following simple method was devised by E. H. Nutter: The arrangement can be seen by reference to Fig. 15. The compartments, *B B'*, alternately take the solution flow from the feed-pipe. As a compartment fills, the weight of solution overbalances the empty compartment and the box turns through a short arc, discharging as it turns, until it is stopped by the springs, *S S'*. Each

discharges registered. In this way leakage, splash, and all other irregular factors are averaged and determined.

A number of devices are upon the market for weighing liquids. The Richardson Automatic Scale Company have designed a liquid weigher. This apparatus is shown in Fig. 16. It consists of a strong iron frame, supporting the equal-armed beam, *A*. To one end of this beam is hung the weighing tank or hopper, *B*, in

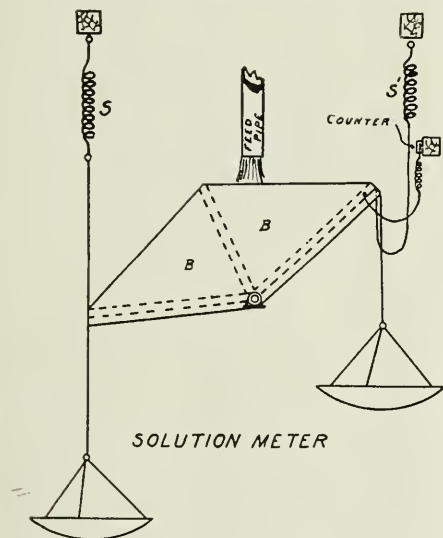


Fig. 15—Simple Device for Measuring Flow of Liquids.

time *B'* discharges the counter registers one. The meter is set up over a vat, and the pans shown in the diagram are always submerged. Their retarding effect is necessary to avoid excessive jar. A dash-pot would probably do as well, or else the box could be made of metal with a pear-shaped cross-section, and hung close up to its center of gravity. The latter form would not need the springs or pans.

The constant of the meter is determined by filling the vat under it and dividing by the number of double

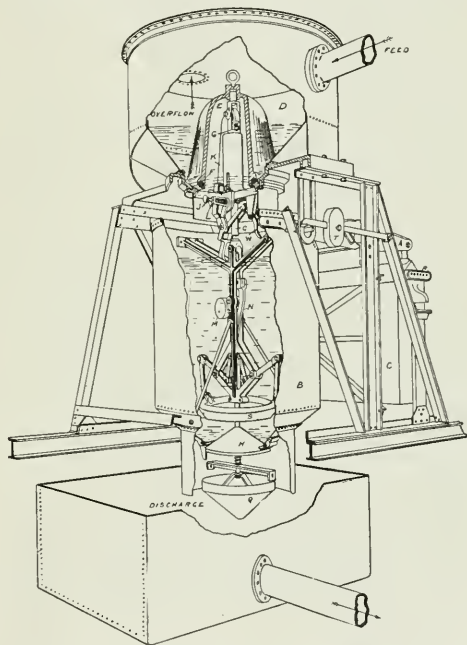


Fig. 16—Richardson Automatic Liquid Scales, Richardson Scale Co.

which the liquid is carried, and to the other suspends the counter-balance, or weight box, *C*.

The quantity determined upon is represented by weights placed in the weight box, which furnish the power to actuate the scale. The supply of the liquid into the scale from the upper hopper tank, *D*, which is fed by the feed, *E*, which forms its joint by descending on to the rubber seating, *F*. This valve is raised through the plunger, *G*, by the power of the weight in the box, *C*, and is controlled by means of the levers, *K* and *L*, which form a dead center.

A full stream of liquid enters the weighing tank, *B*, until its weight in the hopper begins to offset the coun-

*This is the fourth series of articles upon the Elements of Chemical Engineering. Former articles treated of the Materials of Construction, Storage of Materials and Conveying Materials. The next series will be upon Preparing Material for Chemical Processes (crushing, pulverizing, etc.).

terpoise, and in doing so releases the plunger, *G*. The valve now partially closes and only a reduced flow enters the hopper until the balance is reached. This final flow may be enlarged or reduced by means of the screw, *J*.

At the balance, the beam trips the arm, *W*, and the valve completely closes. The lever, *L*, it will be noted, engages with the lever, *N*, breaking the lock formed by the dead center of levers *N* and *M*, and the weight of the liquid opens the outlet valve and the contents of the tank are discharged. This discharge is controlled by the conical valve, *H*, which also has a rubber seating, and thus a joint is formed against the wall of the tank at *S*.

It will be seen that the liquid is delivered onto the tundish, *Q*, connected with the outlet valve, *H*, and the weight of the liquid on this tundish has the effect of holding the valve open until all the liquid is drained from the weighing tank. This valve returns by means of the weighed lever, *M*, when relieved of the weight of the liquid on the tundish, *Q*.

The sides of the tank are continued down to prevent splashing. The final dripping of the liquid in descent between the inlet valve and the weighing tank at the time of the cut-off is compensated for by the weight, *T*, acting on the beam, as in the ordinary Richardson scale.

A mechanical counter, *R*, registers every weighing, so that the total weight of liquid that has passed to the machine is at all times to be read at a glance. The tanks are made of galvanized iron or copper, as may be required, and all parts that come in contact with the liquid are of phosphor bronze, and in turn protected by a sleeve through which the liquid is delivered. This scale is self-testing and it is unnecessary to draw off the liquid into an ordinary tank and weigh it in the usual way to check its weight. The machine can be built any size to suit requirements.

This scale is used extensively to weigh cane juice, molasses, vegetable oils of all kinds, brewer's worts, boiler-feed water, etc., but owing to the fact that there is considerable mechanism in the inside of the tank, it seems to be hardly suitable for weighing liquids which are at all corrosive.

An excellent form of automatic liquid measuring apparatus has been devised by Mr. George B. Wilcox, of Saginaw, Mich. This is shown in Fig. 17. It consists of two tanks placed one above the other. The upper or receiving tank, *A*, stores the liquid and automatically delivers it at intervals as required to the lower tank, *B*, where it is weighed and subsequently delivered. The operation of the apparatus is as follows: Liquid is fed into the upper tank, *A*, through the pipe, *1*, and accumulates until it overflows a stand-pipe, *2a*, located in the upper tank and spills into the tank, *B*, below. Here it raises the bell float, *6*, until a shoulder on a rod, *6a*, attached to this float, lifts the valve, *2*, which when seated forms the overflow pipe. This allows the liquid stored in the upper tank to flow

into the lower tank, filling it nearly to the discharge level, *x*, and also sufficient liquid from the pipe, *1*, to flow over the bottom of the upper tank and through the valve, *2*, into the lower tank to reach this level. The cone, *4*, is intended to guide the liquid gently to the weighing tank. As soon as the liquid in the latter reaches the height, *x*, for which the tripping device, *7*, is set, the contents of the weighing tank are discharged through a pipe, *5*.

The automatic trip consists of a manometer, *7*, whose function it is to suddenly vent the air cushion, *C*, in the bell float, *6*. This latter deprived of its buoyancy drops, allowing the valve, *2*, to seat and shut off the ingress of water into the weighing tank. The water in the tank, *B*, promptly fills the space, *C*, and syphons out through the pipe, *5a*. When the level in the weighing tank sinks below the rim of the bell, *6*,

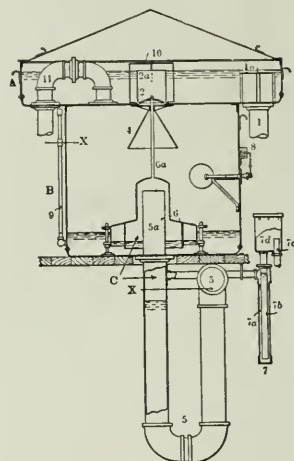


Fig. 17—Wilcox Automatic Liquid Weigher, Wilcox Engineering Co.

air enters the latter and the syphon breaks, and the operation begins over again.

The trip constitutes a hydrostatic balance in which the head of liquid in the tank is delicately balanced by a column of water in the trip. When the former exceeds the latter, the air of course rushes out. The adjustment of the weight is made by varying the height of liquid in the manometer which is accomplished by swinging the tube out of the vertical and thus lessening the effective height.

The number of times the apparatus is filled is recorded by means of the float, *8*, which actuates a counter. This apparatus was first used to measure the brine flowing to a salt works and has been used also for evaporation tests, etc.

GASES.

For measuring small quantities of gas in motion, the ordinary gas meter such as is used for measuring household supplies may be employed. This apparatus is simple and well adapted to measuring most cold

gases, provided they do not attack metal. For large quantities of such gases station meters may be employed, although very expensive. When meters are not practicable, the velocity with which the gas travels through the pipe is determined and if the area of the latter is known, the volume can of course be determined. Such methods are often used for determining the flow of gases through chimneys. The apparatus used to get the velocity of the gases is called an "anemometer," this depends upon the fact that a manometer or U-pressure gauge connected to a tube sticking in the flue, will show higher pressure when the tube is bent towards the gases than when the tube enters at right angles to the flow or bent in its direction. The Fletcher anemometer consists of a U-tube partially filled with ether, the two ends of which are connected respectively to two tubes, one of which enters the tube at right angles to the flow and the other has its end

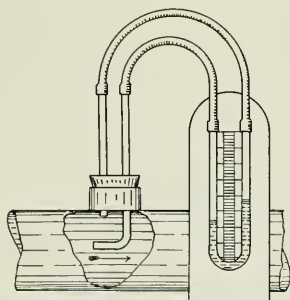


Fig. 18—Simple Anemometer.

bent towards the flow. Tables showing the velocity which corresponds to the reading of this instrument are furnished with it.

A simple instrument is shown in Fig. 18 and consists of a tube filled to about half its height with colored water, and fastened to a board on which a scale has been drawn. If a loose plug of glass or even cotton wool is placed in the bend of the U it will reduce the oscillation of the liquid, which makes accurate reading of the levels difficult. The velocity of the gas in the flue is shown by the following formula:

$$v = 46\frac{2}{3} \sqrt{h}$$

When v = velocity in feet per second and h = difference in level, measured in inches between the water in the two limbs of the U-tube. The volume of gas passing through the flue is of course found by multiplying the area of the flue by the velocity, or

$$V_1 = v \times a$$

When V_1 = volume of gas in cubic feet per second and a = area of the flue in square feet.

This volume of gas is of course measured at the temperature of the flue and must be reduced to standard conditions.

$$V = V_1 \sqrt{\frac{1}{1 + 0.00367T}} = V_1 \sqrt{\frac{1}{1 + 0.00203t}}$$

V = volume of gas at 0°C , T = degrees C, and t = degrees F.

The anemometer is not a very accurate method of measuring the flow of gases due to a number of causes, one of which is that the velocity of gases in the center of a flue is greater than at its sides, etc.

On account of variations in flow only recording instruments are of much value for actual measuring purposes. An instrument depending on the same principles as the above has been brought out by the firm of Paul de Bruyn Duesseldorf, which has proved reliable for measuring gas flow in flues, etc. The working of the apparatus is explained by Fig. 19, which gives a sectional view. The two tubes bent similar to those used with the anemometer are connected to the

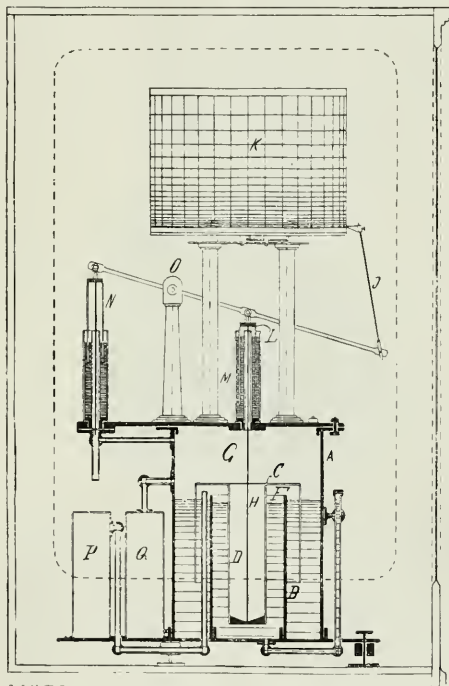


Fig. 19—Gas Meter, Paul de Bruyn.

tanks, P and Q , respectively. These simply serve to take up and equalize any sudden changes in pressure. P is connected to the tube bent towards the gas and communicates with the interior of F , a bell floating in the ring-shaped outer compartment of the compartment, G . The low pressure tube in the gas pipe communicates through Q with D , the hollow chamber which makes the bell float. According to the changes of pressure in F and D the bell will rise or fall and will lift the lever, L , by means of the rod, H . The chamber, G , is kept air tight by the mercury seal, M . In order to avoid the error arising from the varying air pressure on this seal, there is a compensating device consisting of a similar seal attached to the other

end of the lever. The lever communicates with a pen which moves over the revolving drum, *K*. The apparatus is standardized so that the velocity per second is indicated on the recording paper.

The instrument described is especially intended for measuring the waste gases of blast furnaces, which are very largely used for power purposes in Germany, but serves for other gases as well.

An American apparatus which may be used for measuring and recording the flow of either gases under some pressure or steam is the St. John meter, manufactured by G. S. St. John. This is shown in Fig. 20. In the St. John meter air enters at the bottom and following the direction of the arrows leaves at the top. A brass valve, *V*, called the meter-valve, with tapered shank or plug supported by a spindle running in guides in the castings, operates in such manner that when in its lowest position the top of the tapered plug fits closely within the brass valve seats so that no air can flow. As the meter-valve is raised the space

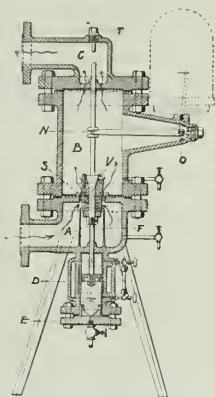


Fig. 20—St. John Air or Steam Meter, G. C. St. John.

between the tapered plug and the seat increases. This space is the orifice through which the air flows and the taper of the plug is such that the amount of air passing through the orifice per minute is directly proportional to the rise of the meter-valve. That is: if 1,000 cu. ft. of free air will pass in one minute when the meter-valve is raised one inch, then when the meter-valve is raised two inches 2,000 cu. ft. will pass, and with a rise of one-half inch 500 cu. ft. per minute will pass.

This motion of the valve is transferred to a pencil-arm outside of the meter casting, which carries a pencil and needle, by a lever-arm inside the casing, supported at the center of rotation, *O*, by a small spindle at *N*. The horizontal spindle at *O* projects through the meter casing to support the pencil-arm and is provided with a small stuffing box to prevent leakage of air.

The pencil-arm is set at such an angle with relation to the inside lever-arm that when the meter valve is on its seat the needle will be over the zero of the dial-scale. The movements of the valve and consequently the flow of air are thus recorded on a paper chart. Cor-

rections must be applied for variations of pressure and temperature of the gas.

This apparatus is very well adapted to measuring steam supplied to evaporators or to cooking vats or to measuring compressed air. It is unsuited to measuring gases under low pressure, less than 2 lbs.

BELT LACING LEATHER.¹

BY W. EITNER.

Special softness and flexibility are here required, together with great resistance to tearing. Formerly such lacings were cut exclusively from alum or alum-fat tanned leather. These possessed the above named properties, but the alum tanned leather was found in time to become brittle, due to its content of excess of alum and salt. The alum-fat tanned leather gave better results. After the alum tannage and removal of the excess of salts with luke-warm water, the leather is milled with a second water containing 5 per cent chalk in order to neutralize the acid. The leather is then dried somewhat, and milled in a heated drum with a mixture of 3 parts tallow, 1 part fish oil, best applied in two successive stages, the total greasing amounting to 16 per cent the weight of the alum leather. The greasing may be accomplished more rapidly and thoroughly with a fat liquor; a thorough neutralizing of the acid with chalk is here essential. The fat mixture (20 per cent the weight of leather) consists of 12 per cent tallow, 4 per cent whale oil, 4 per cent liquor soap. Combined tannage is sometimes used to give the leather a desirable color. A preliminary tannage with gambier is followed by the usual alum tannage, employing first, a used liquor from a previous tannage and strengthening after a day or two. The drum may also be used, but does not give so good a color.

Transparent leather, which is no real leather, but hide impregnated with glycerine, was used to some extent. It was found to possess great strength, but became hard with time. Neither alum leather or transparent leather withstand the heat resulting from the friction in use.

Chrome tanned leather does not possess the defects of the above described leathers to such an extent.

Cut lacings are sometimes demanded with specially hardened tips. Alum tanned leather is easily hardened by dipping in water of 80° C., which extracts the alum and hardens the leather by heat; this process is hastened by adding 2 per cent of acetic acid. Chrome tanned leather is not hardened so quickly; the tips are first dipped in benzine to extract fat, then dried, and next left several hours in 4 per cent sulphuric acid, followed by water of 80° and stretching to dry.

An appropriation of \$1,407,300 has been made for the work of the U. S. Geological Survey for the fiscal year 1909-10. Included in this sum is an appropriation of \$100,000 for fuel testing investigations.

¹From the Journal of the American Leather Chemists' Association. Abstracted here from Der Gerber.

THE MEASUREMENT OF THE STEAM CONSUMPTION IN AN OPEN COOKING VAT.

G. EVERETT QUICK.

Consulting Engineer, Syracuse, N. Y.

Large quantities of steam are used in various chemical processes, such as the commercial production of soap, benzine, ammonia, stearine candles, glycerine, etc., etc. Factories for such usually have extensive boiler equipment which supplies steam for many diverse uses, such as power, cooking, heating, refrigeration, etc. It is often advantageous to know the approximate distribution to the various consuming points, so that each department may be charged with the correct amount. Occasionally a large plant is equipped with automatic recording steam meters, but in most cases such a refinement is unnecessary. In one large plant using over 5,000 horsepower in the manufacture of soda, the distribution of steam, water, chemical solutions, etc., is measured by taking occasional readings with pilot tubes. This method is too inaccurate when used in pipes smaller than 3-in., or with low steam velocities. The Venturi meter has also been used with some success in the measurement of steam. Where steam is used in a closed coil for heating, the consumption is often measured by a condensation meter.

It is oftentimes desired to measure the steam consumption in a cooking vat, where steam is supplied through an open coil. The writer was called upon to make a test of this nature, where the steam velocity was low and a suitable steam meter was not available. This test was made in an industrial plant where steam equipment to 800 h. p. is used for power, refrigeration, lighting, heating, cooking, etc. The steam consumption was thought to be excessive, but owing to the diverse uses and intricate distribution, it was difficult to locate the point of greatest excess loss. The chief product, stearic acid, commercially known as stearine, for making candles, and the by-products, glycerine, red-oil, etc., are obtained from the crude animal fats. There are several good processes and innumerable modifications of each for their production on a commercial scale. The process used in the plant under discussion followed four important steps, —saponification, cooking, distillation and condensation. The only step which will here receive our attention will be the cooking, as the principle excess steam loss was thought to be in vats used for this part of the process. The method used in obtaining the results given below, while limited in application, may nevertheless be used in many other chemical processes.

APPARATUS.

The vats in question were built up of wooden staves about 3 ins. thick, and the vat on which the test was made was 9 ft. in diameter and 9 ft. deep, inside measurements. Steam was led through a 1½-in. pipe to the bottom of the vat, where it was discharged from several openings into the solution. The old method of regulating the flow

was by a hand-regulated valve, which was apt to receive insufficient attention from the attendant, with a resultant wide variation in the temperature and unnecessary waste of steam. The vat under test, however, was equipped with an automatic temperature regulating device manufactured by Holman & Maurer, of Rochester, N. Y. The advantage of this device, together with its use in the test, seems to warrant a short description of it at this time.

The main valve, Fig. 1, located in the steam supply pipe, is of the globe type and is operated by means of water pressure, acting on a flexible diaphragm, against the force of a coil spring on the stem. Fig. 2 shows a novel feature in the ball-joint between the valve stem and clapper. This insures that the valve will always be in alignment, and the

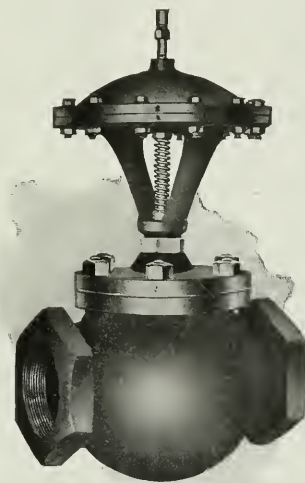


Fig. 1.

pressure bear on the center of the disc. The diaphragm disc in the bonnet of the valve is of rubber where low pressures are used, while it is metallic with high steam pressures. The water pressure operating this valve is sometimes supplied from the tank, but more often from a separate source. It is controlled by the valve shown in Fig. 3 and in section in Fig. 4. In the latter cut, water is taken from the tank the temperature of which is being controlled, while the former, with inlet and outlet pipes, takes water from a separate source. The brass tube, *A*, fastened to the main support, telescopes the steel tube, *B*, and the two are locked together at their outer extremities. The other or free end of the tube, *B*, forms a valve, at *F*, having a seat in the adjustable tube, *G*. The difference in the linear expansion of the two metal tubes due to the variation in the temperature of the solution in which they are immersed, makes a corresponding change in the opening of the valve, *F*, and consequently the flow of water. The water is discharged from the system at

the drip *I'*, near the diaphragm, and as long as its fixed orifice is smaller than the opening of valve, *F*, a static water pressure acts on the diaphragm. The action of the complete device is such that an increase in the temperature of the solution opens the valve, *F*, allowing a greater pressure on the diaphragm and thereby throttling the steam supply. A decrease in temperature results in a reverse action. To maintain the solution at a different constant temperature, the tube, *G*, is screwed in or out, as the change may require, by means of a socket wrench on its outer end. On the opposite side of the vat from the controlling valve is an accurate thermometer which gives the internal temperature of the solution.

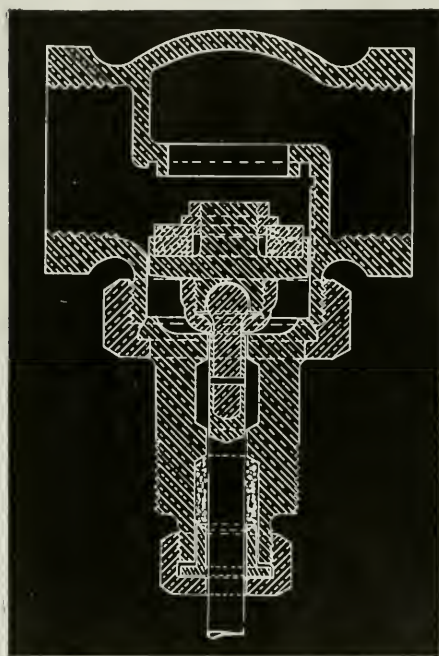


Fig. 2.

After due consideration of the condition and arrangement of our equipment, it was decided that the best method of obtaining the steam consumption was by condensation in the vat itself. On account of the unknown heat constants of the grease solution it was impractical to use it as the condensing liquid. In view of the fact that the amount of steam entering the vat is dependent on the size of the valve orifice, steam pressure, quality of steam, back pressure and time; if these could be determined accurately for the entire cycle of cooking operations, and then duplicated when the grease solution was replaced by pure water, the steam consumption could be satisfactorily determined. In preparation for this test a steam gauge was attached to the steam line, near the diaphragm valve

and on the boiler side. The difference in steam quality was so slight as to be negligible, while the maximum back pressure did not approach 58% of the initial, and its effect on the flow was therefore negligible. The valve opening was accurately determined by a simple multiplying device attached to the valve frame. A piece of rather stiff sheet metal was cut out and fastened to the frame of the valve. An indicating hand is pivoted to the inner end of the piece of sheet metal. The inner end of the pointer is slotted and fits over the pin, fastened between the lock nuts on the valve stem. It is evident that the movement of the valve stem and consequently



Fig. 3.

the valve opening is thus transmitted to the pointer, and with an increase in the motion, due to a 15 to 1 ratio, the slightest change in valve opening is readily observable on the dial. As the readings on the dial were to be the same in the two runs, the graduations were merely arbitrary. In fitting the moving parts of the indicator, care was taken that there should be no back-lash, and to be doubly sure, a rubber band maintained a force on the pointer in one direction.

CALIBRATION RUN.

Following the saponification of the grease and in preparation for the regular cooking process, 5,000 lbs. of water at an average temperature of 130° is introduced in the cooking tank. On top of this is charged 21,000 lbs. of saponified grease. At the time this charging is begun, the steam valve is opened wide so that the solution will be very nearly at cooking temperature (195°) at its completion. During this initial heating up, the thermostatic action of the controlling valve gradually throttles the steam until only a sufficient quantity is permitted to pass to replace the heat lost by radiation at the cooking temperature. The latter is maintained for fifteen hours, when steam is shut

off. After allowing grease and water to separate by settling for an hour, the water (from which glycerine is finally extracted) is drawn off and replaced by another 5,000 lbs. of fresh water. A secondary heating up similar to the first, is required, after which the same cooking temperature is maintained for approximately nine hours longer, when the process is complete. During the entire process, observations were taken of the steam gauge, indicator and thermometer, the frequency of which depended on the steadiness of

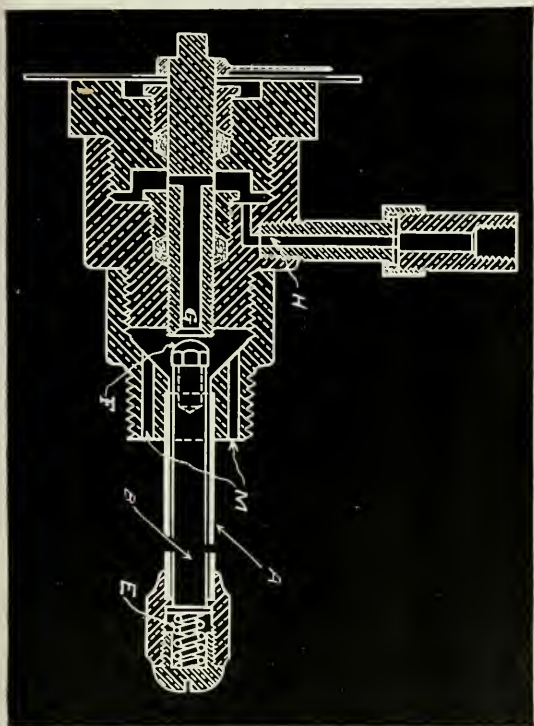


Fig. 4.

the pointer—every two minutes during the heating up periods, and ten to fifteen minutes during the constant temperature period.

TEST RUN.

Following the calibration run, the vat was cleaned out, and the internal dimensions accurately determined for use as a barrel calorimeter. After filling with cold water to within about 2 feet of the top, the actual depth was compared to the reading of the graduations of the float. The scale of the latter is graduated in thirty-seconds of an inch and is frequently checked to make certain that the relative float level has not changed. Knowing the internal cross-section of the vat at any depth of water, the increase in volume of water can be determined by multiplying this cross-section by the increase in depth, as given by the float readings.

At the outset, very careful readings were taken to determine any leakage of water from the tank. Steam was then admitted and the valve so controlled by hand that the indicator readings passed through exactly the same changes as in the calibration run. After continuing the test for only a couple of hours, it became evident that the results would be unsatisfactory owing to the condensation of the steam in the pipe before it is discharged, due to the surrounding cold water. The water slugs increased the back-pressure with a resultant decrease in flow. To overcome this difficulty the initial temperature of the condensing water was raised from 65° to 175° and the test repeated and brought to a satisfactory conclusion. The final temperature was not high enough to cause an appreciable loss of vapor from the surface. Boiler pressures were practically the same in both tests.

Record of the calibration run showed that the indicator readings were constant while the solution was at constant temperature, only sufficient steam being added to compensate for the heat lost by radiation, from the vat. Consequently this part of the run was abbreviated to two hours and the total steam consumption for about 54 hours of cooking, obtained by multiplying this result by the required constant. Immediately following the test run, another trial for leakage was made to make certain it had not changed with the increase in temperature.

For comparative purposes it is advisable to transfer the results, computed in cubic feet, from the linear dimensions of the vat, to pounds of water. Since the weight of a quantity of water is dependent on its temperature, the volumes of water at the beginning and of a test period must be separately transferred to weights and the difference will be the true increase. Convenient tables in any hand-book on steam give weights of water at various temperatures. This increase will be equal to the steam and entrained water passed through the throttle-valve during that period. While the heat delivered by wet steam is less than by dry, this is a loss which will exist in practice and is therefore chargeable to the process.

After making all corrections for leakage, etc., the net weight of steam required to raise the solution to the cooking temperature (including both first and second boils) was 1,355 lbs. The net weight of steam required to maintain a cooking temperature of 195° was 133.9 lbs. per hour, or for a total of 23.8 hours which happened to be the duration of our calibration run) was 3,190 lbs. The total steam required, therefore to cook 21,000 lbs. of grease is the sum of the two or 4,545 lbs.

With a knowledge of the economical performance of the boilers supplying the steam, the cost of this process could be easily computed. Not having this information, and taking boiler pressure at 80 lbs. and feed-water at 150°, the equivalent evaporation "from and at 212°" referred to steam tables, is about 5,000 lbs. Taking an average boiler performance of about

9 lbs. of steam per pound of good coal, the coal consumption would be about 550 lbs.

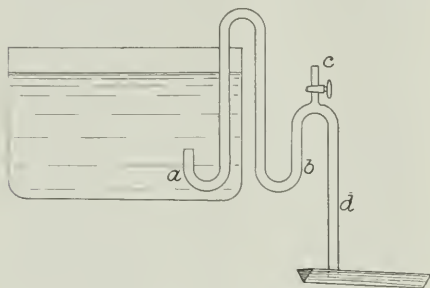
It is of course understood that the figures obtained are somewhat approximate when applied to the process in general. Results would differ somewhat with condition and size of vat, atmospheric conditions, initial temperature of charge, etc.

AN AUTOMATIC SIPHON.¹

BY CARL REINHARDT.

In the chemical industry, the necessity of certain devices for the conveyance of a solution, is often met. A simple automatic syphon for this purpose is shown in the accompanying illustration. It takes up far less space than most apparatus for this purpose, and is therefore specially adapted for use where room is limited. By its use the contents of several vessels can be made to flow into one reservoir, by connecting the outlet of the automatic syphon with a trough or pipe.

In the figure, the fundamental features of an auto-



Arrangement of Automatic Syphon.

matic syphon² are shown from *a* to *b*. The upwards projecting parts of this can be shortened as required. At *c* is an opening which not only prevents the syphon from running empty, but also causes it to continue its action automatically, while *d* shows a convenient extension of the syphon.

This device is well adapted for the continual refilling of vessels and the like, as it can never run empty and starts to work automatically as soon as the solution in the reservoir rises above the level of the mouth of the syphon. Moreover it is specially to be recommended for decanting solutions from precipitates, mother liquors, slimy precipitates, etc., where the settling only take place gradually. In such cases, the automatic syphon has to be lowered gradually, as the settling of the suspended matter takes place. This is done by fastening a cord or a chain to the highest arch of the syphon. This device is of special advantage for such operations, because it enables the suction of the solution to take place from above, not like other syphons from below, thus preventing disturbance of the precipitate. It also can be used as an overflow

syphon. If the diameter of the automatic syphon corresponds with that of the supply pipe an overflowing of the collecting vessel is made impossible as the syphon does not then require any further personal attention.

When in action the syphon sucks air in at *c*. It is also possible to make an accurate mixture of solutions if the opening *c* is conveniently connected. If it is desired to hasten the flow of the solution, the opening *c* can be closed and after the vessel has become nearly empty, it can be reopened so as to prevent the syphon from running entirely empty. This can be regulated automatically by connecting the cock with a float or the like, in the tank. The syphon can be made of any desired material.

WASTE LIQUORS FROM WOOD PULP MILLS.

J. H. Vogel, in *Z. anorg. Chem.*, XXII, 49, states that the waste liquors from wood pulp mills, if diluted 100 times, are perfectly harmless to fish and vegetation. On the other hand, the indirect nuisance caused by the growth and putrefaction of fungi may assume very grave proportions in a slow-flowing river. The waste liquors at their original concentration are absolutely non-putrescible. The growths are developed by the continuous feeding of the lyes into the channel in a highly dilute form. The best method of preventing growths is to periodically discharge large quantities of the lye into the river instead of the continuous discharge of small quantities. The waste liquors should be collected in a reservoir, freed from fibres, and discharged once or twice every 24 hours, at such a rate that the total dilution of the original lye amounts to 100 times. The author also believes that a neutral or alkaline lye greatly favors the growth of fungi. The free sulphurous acid in these lyes is probably in loose combination with the sugars and is far less poisonous to the fish than pure sulphurous acid. All that is necessary is to insure that the free sulphurous acid does not amount to more than 1 gram per litre of effluent. The basic matters in the river water will then do all that is necessary.

FERROSILICON EXPLOSIONS.

According to G. W. Gray, an English Technologist, only the 50 per cent variety of ferrosilicon has, up to the present time, caused trouble from explosions. Ferrosilicon made in the blast furnace is quite safe to carry, as is the electrically made alloy containing up to about 40 per cent. silicon, and also the alloy containing from 60 to 99 per cent. silicon. The only quality of ferrosilicon, which need be looked upon with suspicion, according to this writer, is that containing between 40 and 60 per cent silicon, and even then only when it has been badly made. When this alloy has not been properly manufactured, it is dangerous to carry under any circumstances, and if packed in air tight iron drums, the danger of explosion would only be increased.

¹Translated from *Chemiker-Zeitung*, XXXIII, 5.

²See *Chemical Engineer*, VIII, 5, 188. (Nov., 1908.)



A STUDY OF THE METHODS FOR THE DETERMINATION OF IRON AND ALUMINA IN PHOSPHATE ROCK.

By WILLIAM C. DUMAS.

N. P. Pratt Laboratory, Atlanta, Ga.

In view of the errors and discrepancies often arising in the determination of iron and aluminum in phosphate rock and the exceeding importance of this particular determination, a study and comparison of the various methods was undertaken. We have here the problem of the accurate determination of iron and aluminum in the presence of phosphoric acid and calcium, and as these determinations are of such importance to the phosphate buyers and sellers, the value of the most accurate method cannot be over emphasized. This work is an attempted study of the conditions of reaction and errors connected with this difficult problem. The sub-committee on phosphate rock analysis, with Mr. F. Veitch as chairman, has been sending out samples of phosphate rock to the other committeemen for analysis. Mr. W. P. Heath of this laboratory (N. P. Pratt Laboratory, Atlanta, Ga.) is on this committee and this work was done under his direction.

SOLUTION.

The first point to be considered is the method of solution of the phosphate rock. This point, although it appears quite simple at first sight, presents several difficulties. The iron in phosphate rock occurs in three forms, as the phosphate, as the oxide especially in Tennessee rocks, and as the sulphide; and the aluminum occurs as the phosphate and insoluble silicate, contained in the clay of the insoluble residue. The clay, of course, contains also some iron. Since the insoluble residues consist partly of clay, any method of solution used will not extract all of the aluminum present as the silicate, and also since to some extent the sand residues contains some iron interlocked in the coarse grains, the fineness of grinding will have some effect on the amount of iron passing into solution. Here is an instance to illustrate the first of these points. Two determinations were made for iron. The solution was made by digesting the rock in concentrated HCl for one hour, at a gentle boil. The iron as oxides in the solution, was 2.61% and 2.69% respectively. The insoluble residue was filtered out and dissolved in HF and H₂SO₄ and the iron determined, giving 0.79% and 0.71% oxide of iron respectively, making the percentages of Fe₂O₃ in the rock 3.40% and 3.40% respectively. The amount of iron and aluminum passing into solution with HCl and H₂SO₄ as solvents also depends on the time of digestion, as the flourine from the contained flourides, will

slowly break up the insoluble silicates and gradually render part of them soluble.

Some analysts use HNO₃ or a mixture of HNO₃ and one of the other acids for a solvent. Now, this is a very questionable procedure, since the pyrites in the phosphate rock is not rendered soluble by the non-oxidizing H₂SO₄ in the manufacture of acid phosphate. So, in the valuation of the rock, the iron of the sulphide should not be included in the analysis. This fact then throws out HNO₃ or any other oxidizing acid as a solvent.

The following method seems to be the most satisfactory and to give the most uniform results: The rock portion used for iron and aluminum should at least pass a 60-mesh screen and preferably an 80-mesh. One gram of this powder is dissolved in 10 cc. of HCl (1—1) and boiled gently for half an hour. There is no great advantage in using concentrated HCl here, for the acid will soon boil down to a constant composition of 20.2% HCl. Then the solution will be practically complete for Florida rock and also for Tennessee rock, except for the iron and aluminum locked up in the insoluble residue, which on continued boiling will be rendered soluble by the action of the HF liberated from the flourides. After half hour's boiling, if the acetate method is to be used, the solution should be carried to dryness, but the residue should not be baked. Preferably, the dryness should be obtained on a water bath, for AlCl₃ boils at 183°, and FeCl₃ at 280°-285° under ordinary pressure. This treatment is to drive off HF, which as we shall see later, very materially affects the results by the acetate method but does not interfere in the Glaser-Alcohol method. After removing the flourine, the solution is taken up in 10 cc. of HCl (1—1) and is then ready for analysis. Sulphuric acid may be used for solution instead of HCl, provided the H₂SO₄ is dilute, about 1-4. The results are then about the same as with HCl. But, now suppose we take the solution down to dryness to remove HF, as has to be done for the acetate method, we will decompose some of the insoluble clay residue with the strong H₂SO₄, with a consequent increase of the amount of iron and aluminum passing into solution. The results as would be expected would be higher, especially in the Tennessee phosphate rocks. This method of solution has seemed to some to be the most rational, since apparently the same acid should be used in the analysis that is used to change the rock to acid phosphate, but the analytical results are not nearly so concordant as when HCl is used as a solvent. But, in the valuation of phosphate rock, what we want is a

solvent that will give strictly comparable results in the hands of different chemists, and while if they are not absolute, if they are concordant, the relative results will do as well as a basis of valuation.

Hydrochloric acid seems to be the best solvent. To obtain absolute results, the iron and aluminum should be determined in the insoluble residue and added to that obtained from the analysis of the solution. This takes considerable time and as HCl gives correct relative results and as all of the iron and aluminum in the rock is not dissolved in making acid phosphate, it seems to be the best solvent to more nearly represent the amount of iron and aluminum dissolved in actual practice.

The next step is to analyze the solution obtained by the method as given above. The accurate determination of iron and aluminum in the presence of phosphoric acid, calcium salts, magnesium and fluorine presents a difficult problem. The first method studied is the well-known Glaser-Alcohol method, used by more analytical chemists probably than any other for this determination.

THE GLASER-ALCOHOL METHOD.

The details as modified and carried out are as follows: One gram of phosphate rock powder, ground to pass a 60-mesh screen, or preferably an 80-mesh, is weighed into a 100 cc. flask, 10 cc. of HCl (1—1) added and the solution gently boiled for half an hour, then cooled. The solution, in this method is not evaporated to dryness to expel fluorine, as that element is subsequently removed and doesn't interfere. Twenty cc. of water are added to the cold solution and 10 cc. of concentrated H_2SO_4 are slowly run in. The solution is allowed to cool and alcohol added nearly to the mark, then the solution is well shaken. When perfectly cool, it is made up to the mark, again well shaken, and allowed to stand for an hour or more. The alcohol solution is filtered through a fluted filter and a 50 cc. portion, corresponding to 0.5 gram, is rapidly pipetted off, and the alcohol evaporated out until fumes of H_2SO_4 begin to appear. Concentrated HNO_3 is then slowly run into the hot solution until all of the alcohol is oxidized. The excess HNO_3 is then boiled out and the solution is allowed to cool. Then 20 cc. of water and 5 cc. of HCl are added and the solution boiled to dissolve the sulphates of iron and aluminum. After diluting to about 125 cc., ammonia is run in to slight alkalinity and then again the solution is made acid with HCl. Then ammonia is again added until the solution contains only two or three drops in excess. The solution, made slightly alkaline, is now boiled until the excess ammonia is expelled, and then after adding one more drop of ammonia, it is filtered, the phosphates washed thoroughly with a 5% NH_4NO_3 solution, ignited, blasted and weighed.

Discussion of the Above Method.—The chief sources of error in the Glaser-Alcohol method are, (1) the carrying down of iron and aluminum in the $CaSO_4$, if the alcohol is too strong and if the solution does not contain the proper proportion of free

HCl, (2) the slight solubility, because of hydrolysis, of the phosphates of iron and aluminum. Then, too, we have a carrying down of silica and calcium salts and the co-precipitation of manganese and magnesium phosphates, although as will be shown later, these impurities are never enough to affect the results more than 0.02% or 0.03%. The precipitation of $CaSO_4$ for a separation from sulphates of iron and aluminum ought to be made in a 50% alcohol solution by the addition of 10 cc. of concentrated H_2SO_4 slowly. The strength of the alcohol in the details given above is approximately 50%. Better still, perhaps, the precipitation may be made in a 70% alcohol solution by the addition of 20 cc. of H_2SO_4 (1—1). Best of all, the $CaSO_4$ should be precipitated from the rock solution in 10 cc. of HCl (1—1), after adding 20 cc. of water, with 10 cc. of concentrated H_2SO_4 drop by drop, and after cooling made up to the required volume with 95% alcohol. Under these conditions, there is a smaller tendency to carry down sulphates of iron and aluminum with the $CaSO_4$.

If on the other hand, the precipitation is made in a 95% alcohol solution, sulphates of iron and aluminum are carried down in considerable quantity, especially sulphate of iron. Ferrous sulphate is insoluble in strong alcohol. The following figures show the extent of the error which may result if the alcohol used is too strong. Percentage is given as oxides by weighing combined phosphates.

Con. C_2H_5OH	Dilute C_2H_5OH about 50%
90 %	
4.51	5.98
4.56	6.10
4.93	5.90
4.82	6.06
4.91	5.91
---	---
Av. 4.75	Av. 5.99

Again, the solution should be about 50% alcohol and contain 4 to 5 cc. of concentrated HCl. Under these conditions there is small tendency to lose iron. Three sets of phosphate rock portions were taken and all of them dissolved in 10 cc. of 1—1 HCl. After boiling half an hour, set No. 1 was diluted with 20 cc. of water and the iron and aluminum obtained by the above method. Set No. 2 was evaporated to dryness to expel HCl, then 5 cc. of H_2SO_4 added, the solution washed into a 100 cc. flask with 95% alcohol, and 20 cc. of water added, then 5 cc. more of concentrated H_2SO_4 added. Set No. 3 was evaporated to dryness and treated like set No. 2 except no water was added. The iron and aluminum were determined together as phosphates, then the iron was determined by titration.

No. 1.	No. 2.	No. 3.
Regular method.	HCl absent.	Conc. alcohol and HCl absent.
5.98	5.69	3.32
6.06	5.70	3.22
---	---	---
Av. 6.02	Av. 5.70	Av. 3.27

Contains 2.46% Contains 2.44% Contains .34%
 Fe_2O_3 Fe_2O_3 Fe_2O_3

So, from the above results, it would seem that it is absolutely necessary to have free HCl present and use dilute alcohol, about 50% strong.

When the CaSO_4 is precipitated in alcohol solution of 75% or stronger there is a strong tendency for it to form a slimy precipitate, clogging the filter and oftentimes running through. In the 50% alcohol solution the CaSO_4 is perfectly granular and does not run through. This slimy precipitate in alcohol may and probably does form something of a colloidal solution, as has been shown by C. Neuberg, to be the case with CaCO_3 precipitated in an alcohol solution.

There has been a great deal said about the extent to which the results in the Glaser-Alcohol method are affected by the co-precipitation of impurities with the phosphates of iron and aluminum. In this laboratory, quite a large amount of phosphate rock analysis is done and consequently the ignited phosphates of iron and aluminum accumulate. It was decided to settle the question about the error due to impurities, by the analysis of these residues. The residues were mixtures from Tennessee blue and brown and Florida pebble rock, as obtained from ordinary routine work as carried out every day.

The impurities determined and those likely to be present were titanium, silica, manganese, calcium and magnesium. The TiO_2 was determined by solution of the residues in HCl, evaporation to fumes after addition of H_2SO_4 , oxidizing with H_2O_2 and comparing with standard TiO_2 solution. The correction for the color of the sulphate of iron was applied and the TiO_2 from the residue was determined by fusing with potassium bisulphate, and comparing with standard TiO_2 solution.

A 2.5 gram portion of the residue was used for the determination of SiO_2 , manganese, calcium, and magnesium, and the P_2O_5 was removed by the Rose mercurous nitrate method. The insoluble mercurous phosphate was filtered out, NH_4Cl added, and a slight excess of NH_4OH in order to precipitate traces of aluminum and P_2O_5 remaining in the solution. A double precipitation was made here in presence of a large excess of NH_4Cl , so as not to lose manganese and magnesium. The manganese was separated as MnS by $(\text{NH}_4)_2\text{Sx}$, and weighed as Mn_3O_4 . The calcium and magnesium were determined in the filtrate. Below are the results on the residues. No. 1 are the percentages of the impurities in the phosphates of iron and aluminum, while No. 2 are the percentages, as they would affect the percentage results for iron and aluminum, in a rock of 3% iron and aluminum. No. 1 is the sum of these percentage errors.

	No. 1.	No. 2.	No. 3.
SiO_2	0.790	0.0200	0.0200
TiO_2	0.028	0.0008	0.0008
Mn_3O_4	0.040	0.0012	.....
$\text{Mn}_2\text{P}_2\text{O}_7$	0.075	0.0022	0.0022

CaO	0.970	0.0290	.....
$\text{Ca}_3(\text{PO}_4)_2$	1.790	0.0530	0.0530
MgO	0.220	0.0066	.....
$\text{Mg}_2\text{P}_2\text{O}_7$	0.600	0.0180	0.0180
			0.0940

Flourine, as stated above, cannot affect the correctness of the results by this method except indirectly by attacking the glass and introducing silica. The total error from this cause is small, not exceeding 0.02%, and as phosphate rock contains very little, if any, soluble silica, the results will never be increased in ordinary work, by this impurity more than .02%.

Manganese and magnesium, if present, will be partially precipitated with the phosphates of iron and aluminum, as manganese and magnesium ammonium phosphates. If, however, care is taken to have a large excess of NH_4Cl present, the iron and aluminum phosphates will be only very slightly contaminated, and the washing with NH_4NO_3 will also take out these salts from the precipitates. The total error from these impurities will not exceed .02%.

The largest impurity is calcium, as would be expected. If it were possible to successfully use alcohol stronger than 50% the calcium content would of course be reduced, but, on the other hand, the results would be much too low on account of the insolubility of FeSO_4 in strong alcohol. In the above results, the calcium as phosphate will not affect the results more than .05%.

Now the above results were obtained from mixed residues and from routine analysis. Of course if very great care is exercised, the error from these impurities can be considerably reduced. In any case, the total error due to impurities will not exceed 0.1% in its effect on the results.

In view of the above figures representing the total amount of impurities left in the phosphates of iron and aluminum, when calculated back to percentages as they would affect the percentages of iron and aluminum in the rock, we see that the error from this cause is the smallest in the whole method. There is then clearly no need for a re-solution of the phosphates of iron and aluminum after they have been filtered out and washed, and a reprecipitation with NH_4OH . The plan of filtering out and washing the phosphates, redissolving and reprecipitating, after the addition of ammonium phosphate, is entirely useless, when we consider that the error introduced by not doing so is so small that it is the least in the whole method.

To Test the Accuracy of the Above Modifications.—In order to test the accuracy of the Glaser-Alcohol method carried out as outlined above, an artificial phosphate rock was made, containing $\text{Ca}_3(\text{PO}_4)_2$ and ferrous ammonium sulphate. 0.7 gram of $\text{Ca}_3(\text{PO}_4)_2$ and 0.196 gram of ferrous ammonium sulphate, equivalent to 0.04 gram of Fe_2O_3 , were weighed into a 100 cc. flask and the iron determined as in the regular method. No flourine or flourides were added, as it

has been shown that they cannot affect the results by this method.

Taken		Found	Found
$\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4$	Taken	FePO_4	Fe_2O_3
Al_2O_3	equals Fe_2O_3	FePO_4	equals Fe_2O_3
0.196	" 0.04	0.0774	" 0.0409
0.196	" 0.04	0.0774	" 0.0409
0.196	" 0.04	0.0764	" 0.0405

The weights found are in excellent agreement with the weights taken. Next, solutions were made containing 0.02 gram of Fe_2O_3 and 0.0092 gram of Al_2O_3 , with 0.35 gram of $\text{Ca}_3(\text{PO}_4)_2$ and the following results obtained:

Wt. of Fe_2O_3 Taken	Wt. of Fe_2O_3 Found	$\text{AlPO}_4 + \text{FePO}_4$ Weight	FePO_4 Weight	AlPO_4 Weight	Al_2O_3 Found	Al_2O_3 Taken	Dif. Wt.
0.0200	0.0201	0.0630	0.03796	0.02506	0.0105	0.0092	0.0013
0.0200	0.0201	0.0629	0.03796	0.02494	0.0104	0.0092	0.0012
0.0200	0.0207	0.0645	0.03810	0.02540	0.0106	0.0092	0.0014
0.0200	0.0201	0.0631	0.03796	0.02514	0.0105	0.0092	0.0013

The errors are all well within the limits set by the accuracy of the method itself. Moreover, all the error due to impurities in the precipitates of iron and aluminum phosphates, fall on the percentages of Al_2O_3 , making them higher. If we take off the one milligram or thereabouts, which is added on account of the impurities as shown by the analysis of the residues, the amounts of iron and aluminum oxides found and taken will agree remarkably well. In concluding these remarks on the Glaser-Alcohol method, it may be well to suggest that after making the solution of the rock powder in HCl (1—1), and filtering out the insoluble matter, that a few drops of HNO_3 be added and expelled by boiling. This will completely oxidize the ferrous iron and lessen the tendency of iron to be carried down with the CaSO_4 , as ferric sulphate is very much more soluble in alcohol than ferrous sulphate.

THE ACETATE METHOD.

This method is one quite extensively used, but unless closely watched and carefully carried out, will give erroneous results, because the points of neutrality must be very closely approximated, and unless this is the case, the method is useless in the hands of the unskillful operator. The chief sources of error here are the carrying down of calcium salts and the solubility of the phosphates of iron and aluminum in acetic acid.

The acetate method as usually carried out does not aim to greatly correct the two above-named errors. The method as usually used is as follows: After the solution of the phosphate rock, aliquot portions equal to 0.5 gram are taken, two or three drops of HNO_3 added to oxidize the iron, and the solution boiled a few minutes to expel chlorine and oxides of nitrogen. Then after diluting to about 150 c.c. ammonia is added in very slight excess, until one drop of HCl will redissolve the precipitated phosphates of iron, aluminum and calcium. Then 50 c.c. of a saturated NH_4Cl solu-

tion and 2-3 c.c. of 30% acetic acid are added and the solution brought to a boil. About a gram of ammonium acetate is now added and the solution boiled for two minutes. The phosphates of iron and aluminum are rapidly filtered off and washed twice with 5% ammonium nitrate solution. The phosphates are redissolved from the filter in dilute HCl and after adding 0.25 gram ammonium phosphate the operation is repeated. The phosphates of iron and aluminum are finally thoroughly washed with 5% NH_4NO_3 solution, ignited, blasted and weighed.

Now, as a matter of fact, the method as just outlined is open to serious objections. First of all the neutral point must be regulated with greater nicety than is possible by merely getting a point where the phosphates of iron and aluminum disappear on the addition of one drop of HCl. The failure to get this neutral point may lead to serious errors. It has been found best to add two drops of methyl orange indicator here and bring the solution to a neutral point by the addition of very dilute HCl. In this way the exact neutral point may be obtained. The preference, however, is rather to have the solution slightly alkaline than acid, as the addition of acetic acid afterwards will bring the solution to the correct point. The following are some results obtained. *A* is a set in which the solution was slightly acid, and *B* is neutral to methyl orange:

—A—	—B—
5.20	6.53
4.75	6.47
5.00	6.64
4.70	6.39

Per cents are combined as oxides of iron and aluminum. So if we have our solution even slightly acid with HCl, we run the danger of dissolving some of our iron and aluminum phosphates, unless we go to the other extreme and add a much larger excess of ammonium acetate than is ordinarily necessary, in order to bring the solution to the acidity of acetic acid.

Another point to be emphasized is that these phosphates are themselves slightly soluble in acetic acid, and that we should not have any more present than is necessary to dissolve the $\text{Ca}_3(\text{PO}_4)_2$.

With 0.5 cc. excess acetic acid.	Large excess acetic acid.
5.63	4.70
5.46	4.65
5.31	4.75
5.16	5.00
5.70	....
5.10	....

The next source of error to be considered is the carrying down of calcium salts with the phosphates if the acidity is not properly regulated. If we have too much acetic acid, we will get low results on account of the solubility of the precipitated phosphates in acetic acid, and if we do not have enough acetic acid present, we will not completely remove the $\text{Ca}_3(\text{PO}_4)_2$

and the final precipitate will be contaminated with calcium salts.

Flourine has a marked effect on the accuracy of the results as obtained by this method, and its presence will cause the results to run low.

Flourine present, added.	Flourine absent.
5.10	5.83
5.42	5.91
4.82	5.89
4.65	5.92
4.75	5.81
4.91	5.94
Av. 4.94	Av. 5.88

So the presence of flourine makes a difference of about 1% in the results on the same rock, when the analysis in both cases were carried out exactly alike.

In view of the above facts, the method has been modified so as to better avoid these sources of error. The modification is as follows: Aliquot portions of the rock solution, made as suggested under the head of solution, are evaporated to complete dryness, to expel flourine, and the residue taken up in very dilute HCl. Two or three drops of HNO_3 are added and the solution boiled to expel chlorine and oxides of nitrogen. The solution is then nearly neutralized with ammonia, two drops of methyl orange added, and the solution brought to an exact neutral point with very weak NH_4OH water. Then 50 c.c. of a saturated solution of NH_4Cl are added and 2 c.c. of 36% acetic acid. After diluting to about 300 c.c., the solution is brought to boiling and .83 gram of ammonium acetate (two c.c. of 36% acetic acid neutralized with ammonia) are added. After boiling two minutes, the phosphates of iron and aluminum are rapidly filtered out and washed several times with hot 5% NH_4NO_3 solution. The phosphates are then dissolved from the filter in hot 1-1 HCl, and after adding .5 gram of ammonium phosphate, a second precipitation is made, as before except that only 0.5 c.c. of acetic acid, 36%, is added after neutralizing. The precipitated phosphates are finally filtered out, thoroughly washed with 5% NH_4NO_3 , ignited and weighed.

The conditions in this method seem to be better for an accurate determination of iron and aluminum than those usually given. Iron must be present in the ferric condition as ferrous phosphate is soluble in acetic acid, so particular care has to be taken to thoroughly oxidize the iron. The less free HCl we have in solution the better, for then all the phosphates of calcium, iron and aluminum will be precipitated after making the solution alkaline and then getting an exact neutral point. The ammonium acetate would subsequently bring the solution to the hydrogen concentration of acetic acid, but it is best not to have any free HCl in solution. The large excess of NH_4Cl in solution serves two purposes. First, it prevents the co-precipitation of manganese and magnesium phosphates, and

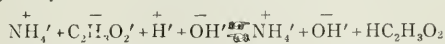
next it lessens the volume concentration of hydron from HCl by introducing large excess of chlorion.

At this point, we have $\text{Ca}_3(\text{PO}_4)_2$, AlPO_4 , and FePO_4 as precipitates in a nearly neutral solution. The point is, to separate FePO_4 and AlPO_4 from the $\text{Ca}_3(\text{PO}_4)_2$ without dissolving any more of the former than is possible, so we must choose the best conditions for this separation. These are the conditions under which the separation must be made. While we wish to dissolve the $\text{Ca}_3(\text{PO}_4)_2$, we wish to weaken the action of acetic acid towards the FePO_4 and AlPO_4 as much as possible. In the first precipitation, we use 2 c.c. of acetic acid in excess, while in the second, after most of the $\text{Ca}_3(\text{PO}_4)_2$ has been removed, we use only 5 c.c. in excess. In order to weaken the action of acetic acid, we add ammonium acetate.

This addition of ammonium acetate is very important. Acetic acid is much weakened by the presence of a neutral acetate. It reduces the strength of acetic acid by adding acetanion and thus reduces the volume concentration of hydron.

Active mass $\text{H}^+ \times$ active mass $\text{C}_2\text{H}_3\text{O}_2^- = \text{K} \times$ active mass $\text{C}_2\text{H}_3\text{O}_2$ (undissociated). If we wish to increase the amount of acetion in a given volume, we can only do so by adding to the solution an acetate which yields metalion, so if we increase the active mass of acetanion, the active mass of unionized hydrogen acetate is also increased, i. e., the degree of ionization per volume is diminished. The conditions should be such that the $\text{Ca}_3(\text{PO}_4)_2$ is dissolved with the least active mass of hydrons. So at first, we use 2 c.c. of 36% acetic acid and after the removal of most of the $\text{Ca}_3(\text{PO}_4)_2$, we use 0.5 c.c. in excess. By so doing, we lessen the tendency of FePO_4 and AlPO_4 to dissolve in acetic acid.

It will be noticed that when ammonium acetate is added to the boiling solution, that the methyl orange turns yellow, showing an alkaline reaction. Ammonium acetate in solution is hydrolyzed to about the extent of .5% at ordinary temperatures for all concentrations. At 100° this hydrolysis amounts to 3.5% in an aqueous solution. According to the dissociation theory, we have the very slight ionization of water itself at 25° increased to about seven times at 100°. Ammonium acetate is strongly dissociated into ammonium ions and acetanions, and the hydron from the water itself, unites with the acetanion to form relatively undissociated acetic acid, leaving an excess of hydroxyl ions in solution. So at 100°, where this hydrolysis is greatest, we have really an alkaline solution although it contains free acetic acid. The free acetic acid which we add to the solution tends to lessen this hydrolysis, but the hydrolysis with this amount of free acetic acid is still enough to give an excess of hydroxyl ions and cause an alkaline reaction.



The hydrolysis probably cannot be 3.5% with 2 c.c. excess acetic acid, yet the solution will show an alkali-

line reaction because acetic acid is so little dissociated.

Next some artificial solutions of phosphate rock were made up approximating the composition of the natural phosphate. Fluorine was removed. Portions of this solution containing .02 gram of Fe_2O_3 , .0073 gram of Al_2O_3 and .4 gram of $\text{Ca}_3(\text{PO}_4)_2$, were analyzed by the modifications as given above, using all the precautions given and taking especial care to strictly observe the above conditions. The results are tabulated below:

Wt. Fe_2O_3 Used	Wt. Fe_2O_3 Found	Diff. Wt.	AlPO_4 FePO_4	FePO_4 Wt.	AlPO_4 Wt.	Al_2O_3 Found	Al_2O_3 Taken	Diff. Wt.
0.0200	0.0201	0.0001	0.0705	0.0380	0.0325	0.0136	0.0073	0.0063
0.0200	0.0201	0.0001	0.0653	0.0380	0.0273	0.0114	0.0073	0.0041
0.0200	0.0201	0.0001	0.0701	0.0380	0.0321	0.0134	0.0073	0.0061
0.0200	0.0201	0.0001	0.0656	0.0380	0.0276	0.0114	0.0073	0.0041
0.0200	0.0200	0.0000	0.0653	0.0378	0.0285	0.0119	0.0073	0.0046

The agreement of weights taken and found are perhaps as good as can be expected from this method. All of the error due to the co-precipitation of $\text{Ca}_3(\text{PO}_4)_2$ falls on the Al_2O_3 , as the iron is titrated and the Al_2O_3 taken by difference. In phosphate rocks we usually have a larger proportion of Al_2O_3 and Fe_2O_3 than here, and in that case the impurity would be about the same as here.

THE GLASER-ACETATE METHOD.

This is a combination of the Glaser-Alcohol and the Acetate methods. The procedure is the same as for the Glaser-Alcohol method until after the oxidation by the NH_4O_3 of the alcohol, then the solution is diluted, neutralized and one acetate separation made with the modifications above. The object of combining these methods is twofold: First, there is less chance for the final precipitates of FePO_4 and AlPO_4 to be contaminated with calcium salts, as most of the calcium is removed in the Glaser method, and the purification is completed in the acetate method. Second, the resulting phosphates obtained by the acetate method filter much faster and better than those obtained at the end of the Glaser method. The results are always very concordant, as will be seen from this set below:

—Glaser-Acetate Results.—	
6.01	6.01
5.93	6.06

Av. 6.00.

When the acetate separation is made here it is only necessary to have the solution very slightly acid with acetic acid, as most of the calcium salts have been removed.

THE CAUSTIC ALKALI METHOD FOR ALUMINA.

This is a very good and exact method for the determination of Al_2O_3 in phosphate rocks, having many more points in its favor than the Thiosulphate method. The method is simple and is easily carried out, and the only difficulty is in getting KOH free from silica and alumina. Caustic alkali by barium should be used, as it is less likely to contain these impurities.

The details of the method are as follows: One gram

of the phosphate rock powder is weighed into a 100-c.c. flask and 10 c.c. of 1-1 HCl added and the solution boiled for half an hour, two drops of HNO_3 having previously been added. After cooling, add 15 c.c. of KOH solution (200 gram KOH in 400 c.c. water) free from silica and alumina, place the flask in boiling water or on a water bath for half an hour. The flask should be frequently shaken. After half an hour, cool and make up to the mark. Filter through a fluted paper, and take 50 c.c. equal to 0.5 gram. Make acid with HCl and add one gram of ammonium phosphate, make slightly alkaline with ammonia, and bring to the neutral point again with HCl, using methyl orange as an indicator. Add 50 c.c. of saturated solution of NH_4Cl , 2 c.c. acetic acid and bring to a boil, then .8 gram of ammonium acetate and boil gently for two minutes. Filter, wash with 5% NH_4NO_3 solution, blast one minute and weigh as AlPO_4 .

In all cases blanks should be run on the KOH. This is a much better and more exact method than the thiosulphate when the alumina is to be determined separately.

A COMPARISON OF RESULTS BY DIFFERENT METHODS.

Sets of results were run through by the different methods as already outlined and the following results obtained. The phosphate rock used was a Tennessee rock and was ground to pass an 80-mesh screen. Figures are tabulated so that they can be easily compared:

Glaser- Alcohol.	Glaser- Acetate.	Glaser- Alcohol.	Glaser- Acetate.	Glaser- Alcohol.	Glaser- Acetate.	KOH.
$\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$	$\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$	$\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$	$\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$	$\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$	$\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$	$\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$
6.06	6.01	6.12	3.07	3.09	2.97	
5.98	6.01	6.04	3.00	3.09	2.90	
6.10	5.93	6.04	3.00	3.03	2.90	
5.90	6.06	5.83	....	....	....	
5.91	....	5.91	....	....	....	
Av. 5.95	Av. 6.00	Av. 5.99	Av. 3.02	Av. 3.07	Av. 2.92	

From the above results, we see that when all the precautions are strictly observed, that all the methods give fairly concordant results.

SUMMARY.

1. There should be uniformity in method of solution. One to one HCl is best for solution, and no oxidizing acid is permissible because iron sulphide would be dissolved. Digestion in one to one HCl should last one-half hour.

2. The phosphates of iron and aluminum are hydrolyzed appreciably by water at the boiling point. They are also soluble in excess of NH_4OH to some extent, forming a compound in which the iron and aluminum form a part of the complex anion from which they cannot be precipitated by ammonia.

3. In the Glaser-Alcohol method the calcium salts should be precipitated in a 50% alcohol solution containing considerable excess of free HCl. When the phosphates are precipitated by ammonia, only the slightest excess is permissible.

4. Phosphates of iron and aluminum should be washed with a 5% NH_4NO_3 solution and not with water.

5. The solutions for the acetate method should be exactly neutral and no more acetic acid should be present than is necessary to remove the $\text{Ca}_3(\text{PO}_4)_2$. It is always best to add ammonium phosphate to the solution of phosphates in HCl before making the second acetate precipitation.

6. There is no more error due to impurities in the Glaser-Alcohol method than there is in the acetate method and this error seldom amounts to .1%.

7. A combination of the Glaser-Alcohol and acetate methods gives excellent results and consumes no more time than either alone.

8. The caustic alkali method for alumina is superior to the Thiosulphate in point of accuracy in the hands of the inexperienced.

9. Flourine should be removed from solutions for the acetate method and the iron should be in the ferric condition. Flourine makes the acetate results run low, but does not affect the Glaser-Alcohol results.

10. Blasting the FePO_4 and AlPO_4 is not necessary if they are ignited strongly over the Bunsen burner for fifteen minutes.

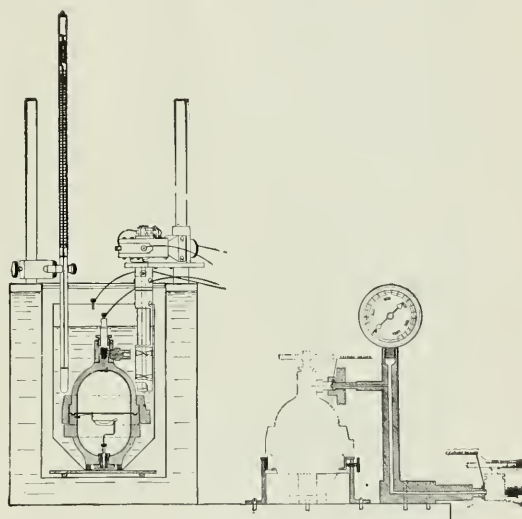
11. The Glaser-Alcohol is the best method of all for iron and aluminum in the hands of the inexperienced.

USES OF CASEIN.

Among the many uses of casein a writer in an English technological journal mentions the following: In the sizing of cotton warps, for which purpose a mixture composed of casein, 16 parts; soap, 8 parts; mineral or other oil, 60 parts; loading, 200 parts; water, 300 parts has been proposed. A good dressing for cotton and linen fabrics may be obtained by dissolving casein with lime, and mixing this solution with that of a hard soap. Casein has also been suggested for waterproofing, the claim being that the goods so treated are impervious to water but remain quite permeable to air, and are therefore more pleasant to wear than rubber goods. A French patent directs that goods be impregnated with an alkali salt of casein, treated with formaldehyde and dried, and then steamed. Chevalott recommends a mixture of 40 parts of casein with 200 parts of water to which is added 1 part of slacked lime and 20 parts of soap dissolved in 240 parts of water. The goods are impregnated in this mixture, passed through a solution of aluminum acetate, dried and ironed. In calico printing, casein may advantageously replace albumin, especially in those goods where the color of the latter is a drawback, or a lessening of the time required for fixing the colors by steaming is desired. Casein is used for the production of non-inflammable photographic films from acetylcellulose and casein. It is also employed to animalize cotton so that it will dye like wool.

THE EMERSON FUEL CALORIMETER.

A new calorimeter has recently been invented by Mr. Charles J. Emerson, which contains a number of features which make it well suited for technical use. In fact, these improvements have been such as to adapt the very accurate Berthelot-Mahler oxygen bomb calorimeter to technical laboratory use. The apparatus is also much more durable and may be handled by those having less experience in calorimetry than is necessary with the Mahler instrument. It is unlike either the Mahler or the Berthelot type in that the receptacle instead of having one main portion with a cover, has its main portion divided and the two halves drawn together by a large nut. This arrangement gives easy access to the interior, makes adjustments easier, and facilitates cleaning. The insertion



The Emerson Fuel Calorimeter.

of the lining, whether it is of spun metal or porcelain, is done with greater precision and ease with this type of instrument. The operator can also insert the fuse wire, platinum fuel pan and charge of fuel, with the lower cup in the bench holder, dispensing with any further moving of the pan, as is necessary when the pan is suspended from the cover or is lowered into position after being filled.

The calorimeter can be tapered at the lower portion to conform to the general shape of the bomb, thereby reducing materially the quantity of water used in the calorimeter. This feature is desirable because the less the quantity of water used, the greater rise in temperature will be produced, and consequently errors of reading, etc., become a smaller percentage of the whole and the error is thus reduced. The stirring is accomplished with a paddle stirrer in a depending tube, which is lowered into the calorimeter, the stirrer being

driven by a directly connected motor. The piping which delivers the oxygen from the supply tank to the bomb, is blocked out as a rigid piece, instead of being of flexible pressure tubing, and unlike the latter it is practically impervious to the development of leaks. The lower cup of the bomb is milled to fit a special holder, which does away with the possibility of jarring, which is liable when using a screw clamp, and also dispensing with the manipulation of the screw.

The apparatus is operated similar to the older type. The charge of fuel is placed in the pan, the fuse wire having been previously wired into position. The upper half of the bomb is adjusted in place and the large nut brings the same home against a lead gasket inserted in a groove on the face of the lower cup. The bomb is then connected to the pipe with the oxygen supply and the oxygen allowed to enter the bomb until the gauge shows a pressure of 20 atmospheres, when the spindle valve is closed at the top and the bomb is ready for the calorimeter.

Comparative determinations made with this and the Mahler and Atwater instruments show very close agreement, and the apparatus may be looked upon as a standard calorimeter, ranking with the former two.

The conditions existing in the calorimeter when the fuel is burning is such that practically no heat is lost. The composition of the fuel does not affect the accuracy of the work. The percentages of ash, water, sulphur, etc., do not materially influence the completeness of the composition, and subsidiary heat giving or heat taking reactions, which are prevalent in bombs using chemicals to supply the oxygen, are also eliminated.

THE QUANTITATIVE DETERMINATION OF NICKEL WITH DIMETHYLGLYOXIME AS APPLIED TO VARIOUS MATERIALS.

O. Brunck describes in the "*Zeitschrift für angewandte Chemie*," 1907, XX, page 834, a method for the quantitative determination of nickel with dimethylglyoxime. If a neutral solution of nickel salt be treated with an alcoholic solution of dimethylglyoxime a red crystalline precipitate is produced. The acid set free in the reaction, however, causes the precipitation to be incomplete and it is necessary to add ammonia in order to get accurate results. The precipitate can be dried at temperatures above 100°C., without decomposition (it sublimes at 250°C.) and has the formula $C_8H_{14}N_4O_4 \cdot Ni$. Cobalt does not interfere, provided that not more than 0.1 gram per 100 c.c. is present. In working the process, the neutral or faintly acid solution containing nickel is heated and treated with a slight excess of dimethylglyoxime. Ammonia is then added gradually until a slight excess is present, the precipitate is collected in a Gooch crucible, washed with hot water, and dried for three-quarters of an hour at 110°-120°C. If nickel and cobalt are both present, they are determined together by electrolysis, the deposit is dissolved in

nitric acid, the solution evaporated with hydrochloric acid, and the nickel determined as described above.

Another article appeared by the same author in the "*Zeitschrift für angewandte Chemie*," 1907, XX, page 1844-1850, on the quantitative determination of nickel in the presence of cobalt, zinc, manganese, iron, aluminum and chromium, by means of dimethylglyoxime.

Nickel and Cobalt. The conversion of nitrate into chlorides before precipitation is unnecessary. If more cobalt than nickel is present, a larger excess of dimethylglyoxime is required, and where the quantity of nickel is small, a method is used in which sodium-acetate replaces ammonia. In this case 0.5 gram of the sample is dissolved in hydrochloric acid and the solution evaporated nearly to dryness. To the hot liquid after being diluted to 400 cc., are added 0.2 gram of dimethylglyoxime and 2 grams of sodium acetate, and the precipitate is filtered off after half an hour. **Nickel and Manganese.** Sodium acetate is used, instead of ammonia to neutralize the mineral acid. **Nickel and Zinc.**—The separation succeeds in the presence of ammonia or acetic acid, but the latter is preferable. **Nickel and Iron.**—To the solution containing iron, in the ferric state, tartaric acid is added before precipitation, to prevent the subsequent formation of ferric hydroxide on adding ammonia. The method is applicable to nickel steels, since manganese does not interfere. **Nickel and Aluminum.**—The method is similar to the "nickel and iron" method. **Nickel and Chromium.**—Tartaric acid is added as above, to prevent the precipitation of chromium by ammonia, but it is necessary to have a sufficiency of ammonium chloride present also. Nickel in nickel chrome steel may be thus directly determined.

The methods are very accurate and rapid; a determination requires one hour, and the somewhat costly reagent may be readily recovered from the precipitates.

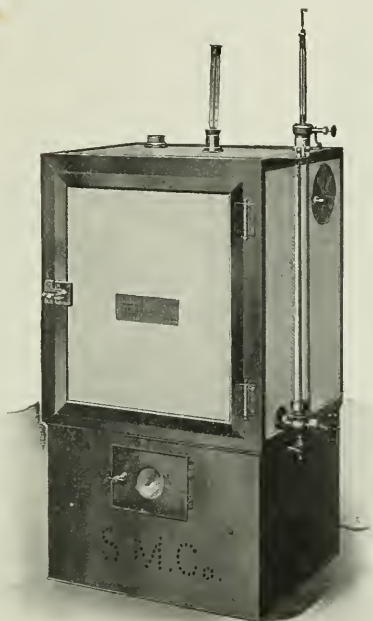
H. Vdoviszevski publishes an article on "The Determination of Nickel in Nickel Steel and Nickel Chrome Steel by Means of Dimethylglyoxime" in "*Stahl und Eisen*," 1908, XXVIII, page 960-961, which is a modification of Brunck's method. The igniting of the precipitate is done in an ordinary platinum or porcelain crucible, instead of using Gooch's crucible. The sublimation of the nickel oxime precipitate is prevented by careful manipulation. For the separation of nickel from iron Rothe's iron extraction method by means of an ether-acetone mixture is used. After the solution is freed from iron, the nickel is precipitated with the respective amount of a 1 per cent alcoholic dimethylglyoxime solution. In the presence of chromium 0.5 to 1 gram of tartaric acid and an excess of ammonia is added to the solution before precipitation. The method requires about three hours and is very accurate.

The output of the two principal coal producing departments of France—Pas-de-Calais and the Nord—in 1908, was 25,521,606 tons, an increase of about 780,000 tons over 1907.

AN ELECTRICALLY HEATED INCUBATOR.

There is probably no place in scientific work where as fine an adjustment of heat is required as in the bacteriological incubator and cultures have been carried on for a long time under difficulties with the old style gas-heated ovens.

The problem has been solved in the oven¹ shown in the accompanying illustration by using electricity for both the heating and the regulation. This oven is the result of more than four years' experimenting to devise a simple and durable arrangement, which can be adjusted by the operator and can be used on any ordinary lighting circuit, either alternating or direct.



Electrically Heated Incubator.

The incubator consists of a three wall oven made of heavy copper, which provides a water jacket and an air space entirely surrounding the oven which is also thoroughly insulated with heavy asbestos board, finished in white enamel.

The desired temperature (37.2° C.) is maintained by means of incandescent lamps in the base, controlled by a make and break device which is in turn operated by a new mercury regulator. By this arrangement the temperature can be maintained within a small fraction of one degree; in fact, a forty-five days' continuous test made by Prof. H. E. Lowe, of the Carnegie Technical Schools, showed that the variation of temperature in this time was hardly perceptible.

¹Which may be obtained from the Scientific Materials Co., Pittsburgh, Pa.

Another feature of the apparatus is that it does away with the open flame, heretofore used for heating, thus eliminating the great liability of fire, as the operation is continued without interruption night and day.

In water laboratories, an incubator is required which will maintain a constant temperature of 20° C. and this electric incubator is answering this purpose admirably at the Water Purification Plant of the city of McKeesport, Pa., where it is set up in an ice-box, the temperature of the latter being kept below this point.

DETERMINATION OF THE HALOGENS IN ORGANIC COMPOUNDS.

C. W. Bacon proposes in the *Chemical News*, of January 1st, a method for determining the halogens in organic compounds. This method is to some extent an improvement of that of Stepanoff made some years ago, which depends upon the fact that if the compound is dissolved in strong alcohol and to this solution sodium is added, the halogen is reduced by the nascent hydrogen liberated by the action of the sodium on the alcohol according to the following reaction. $R.Hg + C_2H_5.OH + Na_2 = Na.Hlg + C_2H_5.ONa + R.H.$

The details of the method are as follows:

Introduce about 0.2 grams of the halogen compound into a dry pear-shaped (Kjeldahl) flask.

If x is the number of grams of the compound taken, add 156 x c.c. of alcohol (at least 98%) if the compound contains chlorine, or 68 x c.c. if the compound contains bromine, or 44 x c.c. if the compound contains iodine. Connect the flask with a reflux condenser, clamp it over a square of wire gauze covered with a thin sheet of asbestos, and warm with a Bunsen burner until the substance is dissolved.

Introduce very gradually, through the condenser, a total of 19.5 x grams of sodium if the compound contains chlorine, or 8.5 x grams of sodium if the compound contains bromine, or 5.5 x grams of sodium if the compound contains iodine. (These quantities represent about fifteen times the amount of sodium corresponding to the chemical equation given in the preceding section, assuming the substance analyzed to contain 100% halogen.) This operation should be extended over at least thirty minutes. Toward the end of the operation maintain the solution at the boiling point by means of a Bunsen burner, and when the introduction of the sodium is complete boil the solution gently for one hour longer.

Then allow the temperature of the solution to fall to about 50° or 60°, dilute freely, through the condenser, with cold water, acidify with nitric acid, add a moderate excess of silver nitrate, and on complete cooling determine the excess of silver titrimetrically by Volhard's method. If the halogen involved is chlorine, filter out the precipitated silver halide before titrating with sulphocyanate. If the halogen is bromine or iodine, filtration is unnecessary.

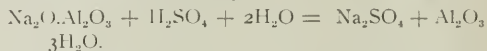
A DIRECT VOLUMETRIC METHOD FOR THE DETERMINATION OF ALUMINA.

Mr. W. H. Seamon proposes a new method for the determination of alumina, in the February number of the *Western Chemist and Metallurgist*. His method starts with the precipitate of iron and alumina obtained by the addition of ammonia to a solution containing ammonium chloride. This precipitate is dissolved in the smallest quantity of concentrated hydrochloric acid, necessary for perfect solution. The solution is collected in a No. 2 casserole and from two to five grams of sodium peroxide, in pulverulent form, is added, a sufficient excess to make a strongly alkaline solution. In adding the peroxide care must be employed to avoid loss by spattering. The solution is then filtered and washed with boiling hot water twice. The filtrate will contain all of the alumina as sodium aluminate, also zinc as sodium zincate, that may have been left in the hydroxide precipitate with ammonia. The precipitate will contain all of the other members of the fourth group, and usually filters rapidly; a filter pump can be conveniently used when more rapidity is required than that afforded by Low's funnels.

The filtrate is collected in a beaker of convenient size, a drop of phenolphthalein added, followed by the cautious addition of the ordinary dilute hydrochloric, or sulphuric acids, to the point where a gelatinous precipitate begins to show, being careful that the pink color of the alkaline phenolphthalein is not removed. Complete the neutralization by running in from a burette a standard solution of sulphuric acid. Should the end point be passed caustic soda may be employed to correct the error. At this point all of the alumina will be in the condition of a gelatinous precipitate. The liquid is then heated to near the boiling point, a drop of methyl orange is added, and the standard solution of sulphuric acid run into the hot liquid until a permanent acid reaction is obtained; the pink color remaining permanent after standing one or two minutes. The alumina dissolves in the acid to a clear solution, and it is always necessary, at the last, to wait a minute or two, with constant stirring, to be sure of the complete solution of the alumina. The amount of standard acid used for this second titration is accurately measured.

For the preparation of the standard solution add 8.3 cc. of sulphuric acid of sp. gr. 1.84 to a liter of water to secure a standard solution, in which one cc. will approximately equal 0.005 gram of alumina. Standardize by dissolving one gram of pure potassium alum in one hundred cc. of water; add one gram of sodium peroxide, add a drop of phenolphthalein and run in acid to the neutral point; then heat to boiling, add one drop of methyl orange and run in the standard acid to permanent acid reaction. Pure alum contains 10.86 per cent of alumina, consequently 0.1086 divided by the number of cc. of the standard acid will give the strength in alumina of one cc.

The method depends upon the fact that sodium peroxide accomplishes a perfect separation of all of the members of the fourth group, except zinc, from alumina, which enters solution as sodium aluminate, with the formula, $\text{Al}_2\text{O}_3 \cdot \text{Na}_2\text{O}$. There is an excess of soda in the solution. The first addition of acid reacts upon it only; so soon as all of it is neutralized the sodium aluminate, which gives an alkaline reaction, begins to decompose with the formation of a gelatinous precipitate, as in the following equation:



It is possible, with care, for the analyst to catch the moment when the acid begins to react upon the sodium aluminate, and he can note the quantity of acid required from this point to the fading of the pink phenolphthalein color, giving a check on the work. The aluminium hydroxide, after the decomposition of the aluminate, is converted into aluminium sulphate, which enters solution.

The aluminum hydroxide dissolves most rapidly in a boiling solution of sulphuric acid. The solution is not instantaneous, consequently it is necessary towards the end of the operation to wait a minute or two, to be sure that the acid reaction is permanent, which it will be, if all of the aluminum has been converted into sulphate.

Should zinc, or lead, be present in the solution as zincate, or plumbate of soda the determination is worthless, as they consume the acid. These are the only interfering substances that can be present.

In the absence of zinc and lead the determination may be made by decomposing half a gram of the pulp, with acids, or by fusion, adding sodium peroxide to strong alkaline reaction, filtering off from the residue, washing with hot water and titrating as previously described.

Sodium peroxide is used because it makes a perfect separation of zinc and alumina from the other members of the fourth group; it is also preferable to sodium and potassium hydroxides, in that it can be obtained freer from alumina than these two caustics. The largest amount of alumina that the author has found in sodium peroxide, as furnished by its manufacturers, was a trifle less than 0.01 per cent of alumina. If no more than two grams of the peroxide is employed the error from its use cannot be more than 0.02 per cent, which is within the limits of error admissible in first-class volumetric work.

Owing to the business depression and over-production in the aluminum industry, some of the foreign producers are turning to other products. The Neuhäusen Aluminum Industry Co. have commenced at one of their works the manufacture of nitric acid and nitrates from atmospheric nitrogen, and are utilizing a portion of their water power for this purpose.

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

PUBLISHED MONTHLY BY

THE CHEMICAL ENGINEER PUBLISHING COMPANY

355 Dearborn Street, Chicago

Entered as Second Class Matter, Aug. 19, 1907, at the Post Office at Chicago, Illinois, March 3, 1879.

Subscription—United States, Cuba and Mexico - - - \$2.00

Extra postage to Canada 25c a year; to foreign countries 50c a year.

Remittances may be made by check, draft, or money order in favor of THE CHEMICAL ENGINEER PUBLISHING CO.

All matter connected with subscriptions or advertising should be sent to THE CHEMICAL ENGINEER PUBLISHING CO., 355 Dearborn street, Chicago. Anything intended for the Editorial Department should be sent directly to the Editor, Richard K. Meade, Nazareth, Pa.

NOTES AND COMMENTS.

PROSCRIBE AND PRESCRIBE.

The tendency of the government to not only proscribe those articles of food and drink which are likely to prove of harm to the people but also prescribe for them what they shall eat and of late in some states with what they shall paint their houses, barns, and fences, seems to be on the increase. Young, brilliant and enthusiastic scientists employed by the federal government and the state experiment stations are continually making exhaustive researches into the relation of food preservatives to the health, and of wood preservatives to the life of the fence, barns, and houses of the nation. These experiments are of course naturally the subject of bulletins, and interesting and important ones too, as the subjects are of direct interest to every one. Of late they have, however, sought a more ambitious termination and are now being made the subject of legislation. Dr. Wiley has brought to a successful issue his national pure food bill and Mr. Ladd has had passed through the North Dakota legislature a paint bill. It is not our purpose to fall foul of any of this legislation, but simply to ask that the chemical profession, better posted upon the subject than any other, and the manufacturer, vitally interested in the matter, as it effects directly his future and possibly his life, stop and consider where this may lead us.

The pure food bill was in many ways a necessity, and Dr. Wiley should receive national thanks for this, as some food products were unquestionably badly abused. Misbranding is undoubtedly a fraud and the man who sells an artificial product for the natural one, is unquestionably obtaining money under false pretenses. The plea that the natural product is often inferior to the artificial has nothing to do with the matter. The consumer should at all times get what he pays for, we do not mean by this that if he pays for bread, the price of a stone, he should get the latter, but if the manufacturer says "I will sell you bread at a dollar a ton" he shall sell him what we legally and in every-day parlance understand as bread.

This legislation should go much farther and be extended beyond the simple needs of the table. If it is a fraud for a manufacturer to sell as Vermont maple syrup "a compound made by boiling" Vermont maple

chips with Louisiana cane sugar, it is also a fraud to sell for white lead, a mixture of 40 per cent barytes and 60 per cent lead, and just as much a fraud to sell for Portland cement, a mixture of 40 per cent Rosendale cement and 60 per cent Portland cement. This legislation can unquestionably be pushed along this line to almost the limit, without harming any honest manufacturer.

So much for proscribing or outlawing the palpable fraud. Now we come to the proscription of food preservatives. When the preservative has been shown to aid a fraud as for instance the coloring of food when practiced with the intention of deceiving the public into believing that inferior goods are of first quality is a fraud. On the other hand, the coloring of food to make it more pleasing to the eye, and consequently more palatable is, if the fact is plainly stated on the wrapper of the package, no fraud but in reality a desire to give the purchaser what he demands. The effect upon the purchaser's health is of course another story and of this, more anon. The addition of formaldehyde to milk in order to make it keep sweet beyond the time in which the untreated milk would sour is a fraud for several reasons, it is usually done to cover up uncleanly and unsanitary conditions of milking and handling the milk and improper methods of transporting it to the purchasers. It also kills the natural enzymes which aid the digesting of the milk and which the purchaser has paid for alive and not dead.

Pasturization for the same reasons might be considered as a fraud. If the milk bottle stated plainly "This milk is preserved with formaldehyde" and "This milk has been Pasturized" respectively, the seller would not necessarily commit a fraud. Now we come to the other side of the question, the effect of the preservative on the health. In the case of the formaldehyde, the preservative is unquestionably a poison and is so generally recognized as such that the placing of a statement that the milk contained it upon the bottle, would cause intelligent people generally to refuse to use it. With pasturizing on the other hand, many people would unquestionably prefer to use such milk rather than to buy the other and have it sour before they used it, either from lack of proper refrigerating devices or failure to use it promptly. Science now seems to indicate that pasturized milk is not as digestible where infants and invalids are concerned as the plain milk, owing to the absence of the natural digestive ferments of the milk, the enzymes. Hence there would seem to be abundant reason for making the milk dealer label pasturized milk as such and in proscribing formaldehyde as a dangerous poison, and in forbidding its use.

Now we come to the other preservatives, the benzoates, etc., which are used in certain foods in minute quantities and here we confess the condition is complicated. It seems that we can all agree to one thing that the quantity of a drug which will enter the system and the need for the preservative must be consid-

ered. Used in such foods as catsup which are taken only in very small quantities the amount of the less active preservatives taken into the system would seem too minute to merit grave consideration. Used in animal products such as cheese, the immunity from ptomaines and toxins forming in the latter would seem to compensate for the harm in any which they would do the health.

This is one view; on the other hand Dr. Wiley contends that these preservatives and coloring principles are deleterious to health, and he has started a vigorous crusade against them; so vigorous in fact, that certain manufacturers appealed to President Roosevelt for a referee board of chemists to whom the question should be submitted. Their request was granted and such a board appointed. This board brought in a report the latter part of January completely reversing Dr. Wiley's ruling against benzoate of soda. The personnel of the board is such that the public and profession can hardly question its ability to render an intelligent verdict. At its head is Dr. Ira Rensen, president of Johns Hopkins University. Other members are Russell H. Chittenden, director of the Sheffield Scientific School of Yale; John H. Long, professor of chemistry in the medical school of the Northwestern University; C. A. Morter, professor of physiological chemistry in the College of Physicians and Surgeons of New York, and Alonzo E. Taylor, professor of pathology in the University of California.

While the decision may be a blow to Dr. Wiley's aims to proscribe food preservatives, he at least has the satisfaction of knowing the case has been tried by a "jury of his peers" and that he as prosecutor has done all he could do. For Dr. Wiley himself we feel sure that even his most bitter opponents in the controversy have nothing but the highest respect. He is an able, experienced and conscientious scientist. What he thinks is wrong, he knows is wrong, and he is so constituted that believing this, he cannot conscientiously subscribe to the views of any one else.

It is not our intention in this discussion to side either with or against the views of Dr. Wiley, but it does seem to us that the time has come when not only the chemical profession, but manufacturers in general should consider very seriously exactly how much legislation which proscribes or outlaws they are going to stand.

In the instance given, the daily papers seem to be of the opinion that Dr. Wiley and even his associates of the Agricultural Department are not of one mind as to the harmful effect of benzoate of soda in food products. It, therefore, seems as if legislation against the preservative was directed solely by one man, and such legislation even if the result of long and painstaking experiments is decidedly unwise. We appreciate Dr. Wiley's point of view as we have stated, for we know him to be an honest and reliable chemist. His experiments have demonstrated to his mind certain views, and as the chief chemist of the department of agriculture, he believes it his duty

to safeguard the health of our people by putting into practice the facts which he has learned from his experiments. On the other hand, there is hardly a chemist among us, who has not made experiments, and proved conclusively to his mind, at least, certain facts, yet he has never been able to get many other equally clever and well trained chemists to accept as final his conclusions, or even for that matter the majority of chemists to accept them. Even the best scientists make mistakes, and the most carefully made experiments sometimes lead to wrong conclusions.

There are a great many chemists who have never been at all satisfied with the poison squad method of investigation adopted by Dr. Wiley. As one of our friends put it, he thought it highly probable that if a government clerk, who had been wont to gulp his mug of coffee and triangle of pie while sitting on one of the arm chairs which line the walls of the little chop houses so numerous around the government buildings at Washington, were put on a diet of broiled live lobsters, that the result in a few weeks time would be even more serious than the benzoate of soda treatment. Our friend seemed to fear greatly that if such an experiment should be made there would be legislation adopted which would prevent the serving of broiled live lobsters, a matter in which he was very much interested.

It is not simply a case of pure food laws, the paint legislation in certain states of the west, which seems to be on its way eastward, is even more severe and has less actually back of it. The American farmer, who during the past few years has paid off his mortgages and even invested in stocks and bonds, seems to need particularly the watchful eye of the government to protect his interests and guard him from the wiles of the dishonest manufacturer. Formerly we were taught to picture Reuben as the purchaser of gold bricks, but, of late, rural trolley lines, good crops and high prices for farm products, coming hand in hand, have enabled him to send his sons to college and his daughters to the seminary, with the result that we no longer consider him a lamb among wolves when he comes to the city. Still our legislators seem to think he needs guarding and hence the paint legislation, designed to protect him from dishonest paints, and proposing as a remedy that the paint can shall have upon it the analysis of the paint which it contains. Presumably the farmer boy, having attended college, knows all about the analysis and can learnedly pick the paint best suited to his needs. Here, however, will come in the chance for the government to prescribe, and by the publication of bulletins inform the farmer of which paints are best suited to his use. In short the proposition is to put the analysis on the can and prescribe the analysis best suited to the barn, the fence and the dwelling.

Now as to the analysis matter, if it is right and proper for the paint manufacturer to place his analysis on the can, it is also right and proper for the farmer to stamp on his eggs the day they were laid, or on his

butter the day it was made, or even tell us how much fat his milk contains, etc. If paint must be sold him by analysis why not make the fence wire people send an analysis along with their goods also, as we believe Dr. Cushman has shown there is a relation between chemical composition and corrosion of fence wire. The fertilizer people should also be forced to put the real, not the advertised analysis, on their bags, the seed people should have their seeds tested and certified to, etc.

Is it fair also to protect only the farmer, why not make laws for the rest of us? The coal dealer should furnish us an analysis of the coal he is delivering since there is a considerable difference between coal with 10 per cent ash and coal with 20 per cent. The gas company should send or publish daily analyses of the gas they propose to give us for our quarter dropped in the meter, etc. More important than all, more important even than benzoate of soda in food, the water company should be made to furnish a certificate showing that their water is pure and wholesome, or, if not, at least warn us to boil it.

We cannot see what right the government has to demand that every package of paint shall have on it its analysis, so long as the paint is not misbranded. The manufacturer may have accumulated secrets which are of value in his trade. It is hardly reasonable to ask him to give his secrets to any man who is willing to pay 15 cents for a small can of paint. Again, let us suppose that the A. B. Co. has spent thousands of dollars advertising "A. B. Paints" and the latter have been tested and found good. The expense of this advertising must be borne by some one, certainly not the manufacturer and therefore the dealer or the consumer. If the paint is sold for the same price as other standard brands of paint, the dealer pays for the advertising by having to pay a slightly higher figure for it wholesale. Now let us suppose the analysis appears on the can, the C. D. Co., another paint manufacturer copies it, or perhaps their paint has been just as good all along but they never advertise. They can undersell the A. B. Co., therefore, if they can sell at all, and perhaps the dealer makes a larger profit by selling the C. D. Co. paint. A customer asks for the "A. B. Paint," the dealer holds up a can of A. B. Paint and a can of the C. D. Paint, and points to the analyses, shows the similarity and offers the C. D. Paint at a lower price. In short the C. D. Co. will get the benefit of their competitor's knowledge and advertising; which looks to us like a "bunco game" on the A. B. Co.

As to the prescribing which government, state and municipal laboratories are now doing, much of it is an unwarranted thrusting of a private opinion backed by the stamp of authority and the appearance of a judicial scientific verdict into the business life of the nation. Some scientists are constituted with a judicial mind and some are not, some can patiently sift the results of many experiments, and going slowly prove each step by cautious tests and more experiments,

never accepting a result as final until forced to do so by many repetitions of the same phenomena. Others rush to the solution of a problem with enthusiasm and fearlessness, accept as final the results of a very limited series of experiments, draw on their own imagination and the literature of the subject and get out a paper or a bulletin. These latter are issued as state documents and widely circulated, possibly under a franking privilege.

A scientific investigation is never entitled to any more weight than the man who makes it. Let John Jones make a report as John Jones, and it will probably carry very little conviction. Let him make it as John Jones, chemist of this or that department of the U. S. Government, or of some state, and the report immediately will become, in the popular mind, endorsed by the state or nation.

The cement industry came in for a bad dose of this in the "Mountain that was made out of the mole hill," at Great Falls, Montana, where a small, indeed a very small, concrete job failed and the onus of it was put on the action of the alkali waters of the section upon the concrete. Of course a bulletin was published, this time a state one, and the clay-ware industry, badly pushed by concrete, made a stand and widely circulated the bulletin, or at least the information that concrete was attacked by the alkali waters of the west. Now the fact of the matter is that, the single instance should never have been anything more than the starting point of an investigation and but little weight should have been attached to the matter. The failure of the sewer was certainly a cause for investigation but the investigation really did nothing more than indicate a remote possibility that concrete would be attacked by the ground waters of that section. The investigators were men of very limited knowledge of concrete or the properties of cement and do not seem to have considered any of a dozen natural causes which might have caused the failure of the sewer, and which have caused similar failures where no ground waters were present.

Another instance of the same faulty method of prescribing is found in a recent paper published from the Chemical Laboratory of the Government of Manila, in the Philippine Journal of Science, a semi-government publication. This bulletin among other things prescribes that cement containing more than 7 per cent alumina should not be used in the tropics. As a matter of fact, some of the best American Portland cements which have been extensively used in Mexico, Central America, and South America contain at least $\frac{1}{2}$ per cent more alumina than the amount laid down. Many of the best export German cements, also, which have been sent to almost all parts of the world and all climates, contain more than 7 per cent alumina. The objections raised to such cements is that they set too quickly; as a matter of fact the cements tested by the authors of this bulletin set quickly from another reason than the high percentage of alumina. The result of such a bulletin is usually that some manufac-

turer with an article no whit better than that of his competitor, except that it falls within the requirements laid down by a particular government bulletin, will use the latter for advertising purposes. We know that this is just what is being done with this particular Philippine bulletin. In this particular instance the conclusions of the authors were drawn from the tests of only, at the most, a few brands of cement, and the authors, themselves were young men of very little experience in cement testing, and unknown in this connection in this country at all.

It would seem that if the government is going into legislation which proscribes and prescribes, that it must dispense with the one man opinion altogether, and that hereafter there must be a legislature of scientific men, a sort of supreme court of scientists, who are specialists on the subject at hand, who will sit and censor its various bulletins, and recommend or disapprove of publications which may be used by one interested to club the other over the head, or will place undue hardship on manufacturers, many of whom have built up large businesses which are dependent on the use of certain chemicals which might easily be proscribed as harmful.

In a great many instances the manufacturers are as alive to the injurious qualities of the chemicals which they use as any one else, and their chemists can give points to the best government experts in their line, but who for business reasons cannot tell all they know. With them it is a case of the choice of two evils. If people want a bottle of catsup to last a month after they open it, and are willing to eat benzoic acid to get it, it is purely a matter of taste, or if they will not pay for white lead paint, no legislation can give it to them, and the fact that the label is on the can means very little to them. It will, however, allow one manufacturer, who is possibly not a whit better than the other, by some subterfuge, to injure or get hold of the other man's business.

THE ARTIFICIAL SILK INDUSTRY.

It is estimated that the world's output of artificial silk is now about 5,000 tons per annum. In 1906 it was 8 tons per day as against 14 tons per day at present. Two new companies have been registered in England to produce artificial silk. The English output is estimated at 270 tons per annum. The two new English plants will utilize the Thiele and Glanzstoff processes respectively, both of which dispense with the use of guncotton and its solvents. It is probable that the profits on the manufacture of nitrocellulose silk have decreased, while those companies working other processes have mostly increased, and in spite of its brilliance, the guncotton product is slowly being displaced by those prepared directly from cotton. During the past year the defects met with in artificial silk, of low strength and elasticity on wetting, have been favorably modified, while the brightness of the product is as great as previously.

CHEMICAL SOCIETIES.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—Samuel P. Sadtler, Pres.; John C. Olson, Sec'y, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN CHEMICAL SOCIETY.—W. R. Whitney, Pres.; Charles L. Parsons, Sec'y, Durham, N. H.

SOCIETY OF CHEMICAL INDUSTRY, NEW YORK SECTION.—Maximilian Toch, Pres.; H. Schweitzer, Sec'y, 128 Duane St., N. Y. City. NEW ENGLAND SECTION.—F. E. Atteaux, Pres.; W. H. Walker, Sec'y, Box 1189, Boston, Mass.

WESTERN ASSOCIATION OF TECHNICAL CHEMISTS AND METALLURGISTS.—W. D. Engle, Pres.; H. C. Parmelee, Sec'y, P. O. Box 1421, Denver, Colo.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Charles B. Dudley, Pres.; Edgar Marburg, Sec'y, Univ. of Penn'a, Philadelphia, Pa.

AMERICAN ELECTROCHEMICAL SOCIETY.—E. G. Acheson, Pres.; J. W. Richards, Sec'y, Bethlehem, Pa.

AMERICAN LEATHER CHEMISTS' ASSOCIATION.—H. T. Wilson, Pres.; H. C. Reed, Sec'y, Stamford, Conn.

At the meeting of the Society of Chemical Industry held in New York, at the Chemists' Club, on the evening of March the 19th, the following papers were read:

"Dutch Process White Lead," by G. W. Thompson.

"The Influence of Chemistry on the Utilization of Quebracho" (illustrated with lantern slides).

"Reinforced Concrete Industrial Buildings" (illustrated with lantern slides).

Dr. Wm. H. Wahl, for many years secretary of the Franklin Institute, Philadelphia, died at his home in that city on Tuesday, March 23d. He was born in Philadelphia in 1848 and educated at Dickinson College and at Heidelberg University. He became secretary of the Franklin Institute in 1870, and held this position until 1874. In 1882, he again became secretary and held office until 1908, when he resigned because of ill health. Dr. Wahl was widely known as an author and journalist. He was, during his terms as secretary, editor of the *Journal of the Franklin Institute*. He was also associate editor of the *Engineering and Mining Journal* from 1878-1880 and editor of the *Manufacture and Builder* from 1880 to 1895.

The next meeting of the American Chemical Society will be held in Detroit, Mich., June 29 and 30 and July 1st and 2nd.

The annual meeting of the American Electrochemical Society will be held at Niagara Falls, Canada, on Thursday, Friday and Saturday, May 6, 7 and 8. The special feature of the meeting will be a symposium of papers on the electro-metallurgy of iron and steel. The whole of the first day, May 6th, will be devoted to this subject. Among those who will either read papers or take part in the discussions upon this subject are Dr. Eugene Haanel, Dr. Paul Heroult, M. Paul Girod, Dr. E. A. Kjellin, M. C. A. Keller, M.

Gustav Gin, Mr. R. Turnbull, Capt. Ernesto Stassano and Mr. F. A. J. FitsGerald. There will also be an exhibit of electrochemical and electrometallurgical furnaces. A number of interesting excursions will be taken on Friday and Saturday afternoons and a smoker will be held Friday night after Mr. Acheson's presidential address. There will also be a banquet Friday night, and on Saturday night a gorge trolley ride will be made. A large number of papers are promised for the meeting. The sessions will be held at the Clifton Hotel, overlooking the Horseshoe Falls.

A commers was given on March the 13th to Dr. Hugo Schweitzer in honor of the 15th anniversary of his services as secretary of the New York section of the Society of Chemical Industry, the 20th anniversary of his landing in this country and the 25th anniversary of his doctorate. The entertainment was held in the banquet hall of the Liederkranz Club of New York City and was attended by some 300 chemists. Mr. Elwood Hendrick presided. Würzburger beer was served, and later in the evening a cold dinner.

Prof. Chandler was toastmaster of the latter, and among those who spoke were Mr. Thomas J. Parker, who presented to Dr. Schweitzer a silver tea service as a souvenir of the occasion, Mr. Seitz, president of the Liederkranz Club, Mr. I. J. P. Muurling, president of the Farbenfabriken of Elberfeld Co., and Mr. Hermon Metz, Comptroller of New York City.

The summer meeting of the American Institute of Chemical Engineers will be held June 24th and 25th in Brooklyn, N. Y. The sessions will be held at the Polytechnic Institute and an exhibit of chemical engineering apparatus will be a feature of the meeting.

THE CHANGE OF COLOR OF LEAD CHROMATE.

It is a well known fact that freshly precipitated lead chromate gradually changes its color from lemon yellow to orange, and to prevent this in its manufacture it is usual to precipitate a certain proportion of lead sulphate along with the chromate. It has been found that as little as 10 per cent lead sulphate will prevent this change of color. According to K. Jablczynski this change of color is due to the hydrolysis of the lead chromate, which is not completely insoluble in water. The dissolved portion yields in solution lead ions and chromate ions: $\text{PbCrO}_4 = \text{Pb} \div \text{CrO}_4$. By the union of the lead ions and the hydroxyl ions of the water, the basic ions, PbOH , are formed, and these combine with chromate ions to produce basic lead chromate, $\text{Pb}_2(\text{OH})_2\text{CrO}_4$ (the parent substance of "chrome red"). If a soluble lead salt be present, it yields lead ions in solution, and these diminish the degree of dissociation of the lead chromate and thus limit the reactions mentioned. Lead acetate, being easily soluble, can be washed out of the lead chromate precipitate, and the change of color can then take place. Lead sulphate is sufficiently soluble to prevent the change of color, but not soluble enough to be removed by washing.

BOOK REVIEWS.

LABORATORY NOTES ON INDUSTRIAL WATER ANALYSIS.

By Ellen H. Richards, Instructor in Sanitary Chemistry, Massachusetts Institute of Technology, 8vo. Cloth. 52 pages. Price \$0.50. John Wiley & Sons, New York, 1909.

This book represents the best academic practice in connection with potable water analyses. That a complete sanitary and mineral analysis of water is necessary for technical purposes is becoming generally known, and we are pleased to see methods for both forms of analysis taken up in the same book. The terms "organic and volatile" in a mineral water analysis are grossly approximate, and usually misleading. Preferably such tests should include besides the mineral constituents free and albuminoid ammonia, oxygen consumed, nitrates and nitrites.

The sanitary analytical methods detailed in this book are excellent. On the other hand, the methods of mineral analysis seem incomplete and are handled in an unfamiliar way, due no doubt to lack of actual experience among boiler plants. It is safe to say that the methods of boiler water analysis are not representative of the processes used in our best industrial laboratories, making a specialty of such work. Engineers insist on reports that show the mineral constituents of the water. The chemist has never successfully solved this problem, but will probably at no distant date remove each mineral by a suitable solvent or precipitant. Whether the mechanical engineer gains anything by asking for such combinations is a question. Surely the boiler water *treatment* does not require mineral combinations.

Useful tables are appended. If re-edited and strengthened from the standpoint of mineral analysis this book can be made useful and valuable to young men studying engineering.

W. M. B.

PRINCIPLES AND PRACTICE OF AGRICULTURAL ANALYSIS.

Second edition revised and enlarged. By Harvey W. Wiley, A. M., Ph. D. 8vo. Cloth, illustrated. Vol. I, Soils. xii + 636 pages. Price \$4.00. Vol. II, Fertilizers and Insecticides. xi + 680 pages. Price \$4.50. The Chemical Publishing Company, Easton, Pa.

The first edition of this comprehensive work appeared about twelve years ago, but so rapid has been the advance in agricultural science that the well known author is justified in bringing out the second edition, which is a decided improvement over the first, though that was well done. By adding a new chapter on insecticides and rearranging and transferring material from the old first volume to the second, two volumes of approximately the same size have been prepared. While all the latest methods have been added, the old methods are also retained as in many instances illuminating the more modern and short methods of

analysis. In the second volume, one notes with special interest the production of nitric acid for manurial purposes from cyanamid and by the direct oxidation of atmospheric nitrogen by the electric current. It is to be hoped that the author may soon issue the revised third volume of his valuable and authoritative "Principles and Practice of Agricultural Analysis."

ALBERT H. WELLS.

A SHORT PHARMACEUTIC CHEMISTRY INORGANIC AND ORGANIC. By I. V. Stanley Stanislaus and Charles H. Kimberly. 12mo. Cloth. ix + 610 pages. Price \$2.50 net. P. Blakiston's Son & Co., Philadelphia. 1908.

This little manual is the second edition of a book published some eleven years ago. It is intended for students of pharmacy and the text has been based upon the United States Pharmacopœia. The book is divided into two parts, the first of which treats of inorganic chemistry, and the second of organic chemistry, elementary organic analysis, qualitative tests for the elements in organic chemistry and elementary volumetric analysis. The book is neatly printed and well arranged and we have no doubt will prove useful as a manual of chemistry in pharmaceutical and medical schools, to which it is, of course, peculiarly adapted. The book is well arranged, neatly printed and bound. Very thin paper has been used and in spite of its 600 pages the book is less than an inch thick, a commendable thing in such a work. It also may be opened flat, another excellent requisite for a laboratory manual.

THE POWER HAND-BOOKS. 12mo. Cloth. Illustrated. Price \$1.00 each. The Hill Publishing Co., New York, N. Y. 1909.

ERECTING WORK. By Hubert E. Collins. vii + 140 pages.

KNOCKS AND KINKS. By Hubert E. Collins. vii + 137 pages.

PIPES AND PIPING. By Hubert E. Collins. vii + 140 pages.

These three little books belong to the same series as Gill's Engine Room Chemistry. They contain many useful hints for practical work and are compiled from articles which have appeared in "Power." "Erecting Work" describes the methods of erecting machinery and explains clearly the different ways of rigging. It is intended to aid those who desire to erect their own machinery. It not only tells how to set up machinery but also how to lay the foundations and handle heavy and unwieldy parts. While the practical applications are largely to the moving of engine parts, the instructions can be applied to erecting any form of machine.

"Knocks and Kinks" explains the causes and how to detect and remedy the knocks in engines. Among other things it explains how to refit large pistons, re-

pair broken cylinders and rebabbit bearings and gives some kinks on emergency and temporary repairs.

"Pipes and Piping" is devoted to piping for steam and tells how to design the line and select the material for its construction. The books are full of practical suggestions. The language is simple and non-technical. Altogether, they are suitable works to put in the hands of the plant engineer. They will also prove useful to managers who desire to know something more than what goes in the ledgers and balance sheets.

CORRESPONDENCE.

To the Editor of THE CHEMICAL ENGINEER.

Sir:—It has been said, and truly said, that republics are ungrateful. Plainly we must say, so much the worse for the republics. The cause must lie in the inferiority of the average man, and any effort to improve the state of things must consist in an effort to lift the average. This saying seems to express truth for all sorts of republics, the American Chemical Society among the number. The one position in the gift of that society purely an honorary one, requiring very little of the incumbent, is the presidency. Because it is purely an honorary position I have always urged that incumbency should be limited to a single term of one year. The result of the violation of this arrangement has been that a number of those to whom the honor should have been given have never received it. Very likely there are others, but three men still living have richly deserved the honor and should receive it in the near future. The first of these men is Dr. C. E. Munroe of Washington, D. C., whose recent excellent work on the census has given him such deserved renown. At a critical period in the history of the society he lent a hand and by personal advocacy among his friends induced them to join the society and raise it from the Slough of Despond into which it had fallen.

The second is Dr. A. A. Breneman, for a long time editor of the society's journal, whose hard and self-sacrificing work for the society is well known to the older members, but has never had the recognition it deserved.

The third is Dr. A. C. Hale, for a long time secretary of the society. Dr. Hale could ill afford to spare the time and effort which he gave but he was indefatigable in the work. He is beside a most kind-hearted and lovable man. For about seven years I worked beside him and formed a very high estimate of his disinterestedness, unselfishness, loyalty and kindness for which no demand was too large. In some way, if not by the gift of the presidency, then in some other suitable way, the heavy debt we all owe to these men should be acknowledged and paid so that their posterity may be able to have the grateful feeling that our republic at least has not been ungrateful.

EDWARD HART.

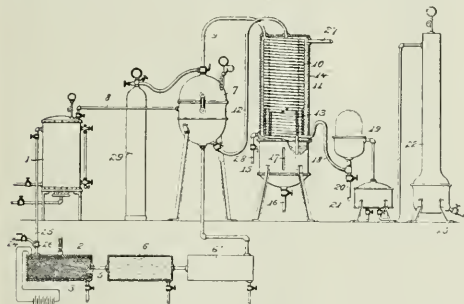
Easton, Pa., Mar. 16, 1909.

INDUSTRIAL NOTES.

ALCOHOL FROM NATURAL GAS.

Carl Von Hartzfelt, a chemist of Wheeling, West Va., has invented a process for the manufacture of alcohol from natural gas, which contains on an average, about 94 per cent of methane. The quantity of alcohol which may be produced per cubic foot of gas will depend upon the percentage of methane which the gas contains, as the percentage of this latter varies largely with gas from different localities. With natural gas containing 94 per cent methane, about four gallons of alcohol will be produced per 1,000 cubic feet of natural gas.

The apparatus for carrying out the process is shown in the accompanying illustration. Mr. Von Hartzfelt thus describes his apparatus and process. It consists of a porcelain or enameled retort (2) containing an electrically heated, closely woven coil of fine German-silver, wire gauze. By subjecting the natural gas to the heat of this, and combining it with oxygen in the



Apparatus for Manufacturing Alcohol for Natural Gas.

presence of a heat absorbing medium, such as steam, the methane and other constituents of the gas are oxidized to a mixture of alcohol, benzol, nitric acid and prussic acid. The steam is used to prevent complete combustion and to maintain the temperature below the decomposing point of the alcohol. From the retort these-volatile products pass through a pipe (5) into a second retort (6) where the vapor is partially cooled and condensed. The products so obtained partially separate here by their difference in density, etc. From the retort (6) the vapors are passed to an "airometer" (7). From this airometer the volatile products are passed under pressure through a pipe (9) to the outer coil (10) of a water cooled "distillator" (11), while the condensed or liquid portion of the product is passed in the form of alcohol, etc., through a pipe (12) to the inner coil (13) of the distillator. From this latter it is then drawn off through an outlet tube or faucet (16). The manometer is provided with a specific gravity meter (17), in order that the separation of the liquid into its various constituents may be facilitated. For further refining the product of the distillation, it is passed to the overflow vessel (19), which is of a vacuum type, and provided with an out-

let tube (20). From the overflow vessel it is conducted through a filter (21) and from this through a hydrometer (22) provided with pipe and faucet (23). A plant for the manufacture of denatured alcohol by this process is now located at Wheeling, West Va.

A CHEMICAL CALENDAR.

We have received from Messrs. Eimer and Amend, dealers in laboratory supplies, 18th street and Third avenue, New York city, a neat calendar containing a novel table of the International Atomic Weights. This table gives the values with both oxygen equal to sixteen and hydrogen equal to one. The figures have the values of those of the 1908 report. The novel feature of the calendar is the printing of the names, symbols and atomic weights of the various elements in different colors. All those elements belonging to the same group in Mendeleeff's table are printed in the same color ink, thus, the elements of group one in black, of group two in yellow, of group three in green, of group four in red, of group five in purple, while the ungrouped metals are printed in blue. This color scheme gives a very pleasing effect and also allows the chemist to see at a glance which elements belong to the respective groups. The calendar can no doubt be obtained by application to Messrs. Eimer and Amend.

GERMAN FIRMS ESTABLISH AMERICAN BRANCH.

Siemens & Holske Co. and the Siemens-Schukert Co. of Germany have opened American offices with their headquarters at Room No. 1559, Hudson Terminal Building, New York city. The offices will be in charge of Dr. Carl G. Frank. Among the appliances which these concerns intend to push especially in this country are the well known Siemens's ozone apparatus for purifying water, high-grade laboratory and switchboard instruments, Roetgen apparatus, induction coils, and other electrical appliances.

WORK ON ESSENTIAL OILS.

We have received from Messrs. Schimmel & Co. (Fritzsche Brothers), Miltitz (near Leipzig), London and New York, their semi-annual report. This is a neatly printed pamphlet bound with limp board covers, containing some 230 pages devoted largely to commercial notes and scientific information on essential oils. It is arranged alphabetically and probably contains more information on this subject than can be found elsewhere in the same space. There are also a number of pages devoted to the newer essential oils. A special section is devoted to notes on recent research work concerning terpenes and terpene derivatives, which is a review of all the recent research work, with references to literature, done in connection with these compounds. This section occupies some 46 pages. The following and last section of the book is an interesting account by a Japanese chemist, Naojiro Inouye, of Japanese peppermint, its cultivation, harvesting, etc., and the distillation of peppermint oil from the same, and the extraction of menthol or Japanese camphor from the oil.

INDUSTRIAL AND PLANT NEWS.

Alloys. The Monel Metal Manufacturing Co. has been incorporated in New York by Edmund C. Conyers of Greenwich, Conn., Joseph R. Delamar of New York City, and Elias M. Johnson of Spuyten Duyvil, N. Y. Monel metal castings will be manufactured. This metal is an alloy of copper and nickel, which is said to resist corrosion to a greater degree than other alloys.

Brick. L. I. Dirting and F. H. Robins will establish a brick plant with a capacity of about 100,000 bricks daily, at North Mountain, W. Va. The cost of the plant will be about \$100,000.

Brick. The Wilkes-Barre Brick Company, of Wilkes-Barre, Pa., with a capital of about \$100,000, has been incorporated by R. A. Reed, G. W. Gotthold, W. H. Ainesbury, and D. H. Evans, of Wilkes-Barre, and A. D. Thomas of Edgarsville, Pa.

Brick and Clay Products. The Twentieth Century Clay Co., with a capital stock of \$300,000 has been incorporated at Cleveland, Ohio, by C. L. Morton, A. H. and S. F. Moore, D. H. Tilden and Elmer G. Deer.

Brick and Clay Products. The Phoenix Brick and Construction Co., St. Joseph, Mo., propose to enlarge their capacity, and at an early date engage in the manufacture of fireproofing and sewer pipe, in addition to making paving brick. The improvements are estimated to cost between \$60,000 and \$100,000.

Electro Chemicals. The Development and Funding Co., 40 Wall St., New York, has awarded contracts for additions to its plant at Niagara Falls, N. Y., to cost \$75,000. The additions will consist of two four-story reinforced concrete buildings 95x110 ft. and 48x110 ft. respectively and six other smaller buildings with power plant and transformer station. The Development and Funding Co. is interested in the Townsend cell for the electrolytic production of alkali and chlorine.

Fireproofing. The Sagax Wood Co., 106 Dover St., Baltimore, Md., will build a plant to manufacture imitation wood in such forms as fire doors, shutters, fireproof corridors, etc. The plant will cost \$30,000 and will have a capacity of 25 tons per day.

Glass. The California Glass and Soda Mfg. Co. will erect at Los Angeles, Cal., a glass factory to cost approximately \$75,000, for the manufacture of window glass, bottles, jars, etc.

Grape Juice. The Grape Products Co., Erie, Pa., will build a 3-story brick and concrete factory 112x401 ft. and power house to cost \$300,000, at North East, Pa.

Iron. The Stewart Iron Co. of Sharon, Pa., will make improvements amounting to about \$150,000 at their plant at that place. These will include a new steel traveling ore bridge, unloading machinery, and coal, coke and limestone bins. All equipments at the plant will be operated by electricity and work will be started on the improvements about the end of the month.

Ink. The Carter Ink Co. will erect a reinforced concrete factory building at Cambridge, Mass. The building will be of reinforced concrete throughout and absolutely fireproof.

Leather. The Barnett Leather Co. will build a 4-story factory building at Little Falls, N. Y.

Matches. The Star Match Co. recently incorporated, is asking for bids to have a 2-story concrete building, 76 by 196 ft., built at Elkhart, Ind. The building will be fire-

proof. W. W. Sterling and Julius Russel are incorporators.

Oil Refinery. It is understood that an oil refinery to cost about \$250,000, and to have a capacity of 1,000 barrels per day will be built at Ft. Smith, Ark., by a company, in which Chas. T. Madison, of Muskogee, Okla., is interested.

Oil Refinery. It is stated that an oil refinery to cost \$1,000,000 will be built at Santa Barbara, Cal. The promoters are the Rahn Realty Investment Co., Stimson building, who have acquired 4,000 acres of oil land in the Carpinteria district.

Paint. The Oregon Sienna Mineral Paint Co. will erect a paint factory at St. John, Oregon. The building will be 50x60 ft., and with the equipment will cost about \$100,000.

Paper. The Howard Paper Co. will erect a paper mill at Urbana, O., to cost about \$250,000.

Paper. The Orange Yellow Pine Paper Co., Orange, Tex., will spend \$200,000 in enlarging their plant and in additional machinery.

Paper and Pulp. The Dells Paper and Pulp Co. propose erecting a \$200,000 paper and pulp plant at Jim Falls, Wis.

Portland Cement. The Alpha Portland Cement Co., of Easton, Pa., has purchased the plant of the Buckhorn Portland Cement Co., at Manheim, W. Va., and will expend about \$50,000 in improvements upon the latter. The New York and New England Cement and Lime Co., Greenport, New York, have purchased the plant of the Hudson Portland Cement Co., Hudson, N. Y., and will remodel the latter.

Rubber. The B. F. Goodrich Co. is having plans prepared for a 6-story factory, which is to be erected at their plant at Akron, Ohio.

Soap. The Holbrook Mfg. Co. 470 Washington St., Jersey City, N. J., will soon begin the erection of a large reinforced concrete fireproof soap factory, on their property, at 18th and Coles St. The factory will be 55x108 ft. and 7 stories high. The power house will be 28x72 ft.

Soap. The Louisville Soap Co. has purchased the plant of the Memphis Soap Co., Memphis, Tenn., which it will remodel and run as a branch of the first named corporation. When placed in operation the plant will produce about 20,000 boxes of soap per month.

Steel. The Shelby Steel Tube Co., Frick building, Pittsburgh, Pa., is preparing plans for a new open hearth steel plant to be built at Elwood City, Pa., this summer, where this company already has a works.

Steel. The Scott Iron and Steel Co. will be incorporated by John A. Scott and George P. Stelle, both of Pittsburgh, and J. C. Stauffer, of Carnegie, Pa., with an authorized capital of \$100,000. The company has purchased the plant of the Carnegie Tube Co., at Carnegie, Pa., and will remodel it for the manufacture of horseshoes under a new process.

Steel. The open hearth furnace of the Algola Steel Co., at Sault Ste. Marie, Ont., will be extended this year and blast furnaces and a structural steel plant will be erected.

Steel Ties. Leonard W. Ashley, president of the International Malleable Steel Tie Co., has announced that his company intends erecting a plant in Muskegon, Mich., for the manufacture of steel reinforced concrete ties for railroads. The company has a capital of \$1,500,000, and will operate about 20 ovens.

Sugar. The American Sugar Refining Co. will rebuild its plant, which was destroyed by fire recently, at St. Bernard, La.

RECENT INVENTIONS.

The following patents relating to applied chemistry and metallurgy are reported for THE CHEMICAL ENGINEER by C. L. Parker, attorney in chemical patent causes, 908 G street, N. W., Washington, D. C.

910,530—Method of Absorbing Oxides of Nitrogen. Birger F. Halvorsen. January 26, 1909.

The method comprises first treating the gas with water and conducting the gases resulting therefrom into an alkaline absorbent.

910,569—Composition of matter for polishing and Dressing Floors. Ida H. Peco. January 26, 1909.

The composition contains paraffin, white wax, spermaceti, bees' wax and corn meal.

910,662—Process of Making Caustic Alkalies. William T. Gibbs. January 26, 1909.

The process consists in digesting finely divided refractory silicates containing alkalies with solution of an alkaline earth hydrate under pressure.

910,707—Process of Treating Iron Ore. Charles B. Morgan. January 26, 1909.

The process consists in first melting the ore charge to a liquid state and introducing into the melted charge a sufficient amount of carbonaceous substance in a liquid state to effect a reduction of the iron.

910,839—Process of Making Thioindigo Leuco Compounds. Eduard Munch. January 26, 1909.

The process of producing leuco compounds of coloring matters of the thioindigo group by acting with an alkaline condensing agent on an omega-dihalogen-vinylthiosalicylic acid compound.

910,858—Production of Hydrazin. Friedrich Raschig. January 26, 1909.

The process consists in producing hydrazin by heating mono-chloramine with an excess of ammonia.

910,889—Stable Indigo White and Process of Making Same. Robert Wimmer, January 26, 1909.

The composition consists of alkali salt of indigo white and sulphite cellulose waste, which preparation is easily soluble in water and adapted for direct use in a vat.

910,894—Process for Making Titanium Alloys. Frederick M. Brecket. January 26, 1909.

The process consists in reducing a titanium ore in an electric furnace by means of carbon in presence of sufficient silicon to exclude from the product carbon in excess of 10 per cent.

910,936—Dinitroglycerin Explosive and Process of Making. Anton Mikolajczak. January 26, 1909.

The process of manufacturing this explosive consists in dissolving gelatinating media in dinitroglycerin and incorporating solid inorganic oxidizing salt with said mixture.

910,978—Process of Making Isobornyl Esters. Charles Weizmann. January 26, 1909.

The process consists in the heating a mixture of pinenehydrochloride and fatty acids in the presence of metallic zinc.

910,982—Process of Forming Metal Salts. William H. Allen. January 26, 1909.

The process consists in mixing furnace gases carrying metallic fumes with an acid vapor, then reducing the temperature so that the acid vapor and metallic fumes will unite, and finally cooling the gases with a spray of water until the solids are separated from the fixed gases.

910,989—Insulating Compound. Patrick J. Cannon. January 26, 1909.

The compound is moldable into desired shapes by the application of heat and pressure and consists of comminuted inert material and a binder comprising copal gum and a bituminous substance to raise the melting point of the latter.

911,116. Process of Inlaying, Ornamenting and Case-Hardening Metallic Surfaces. Sherard O. Cowper-Coles, February 2, 1909.

The method consists in exposing the surface to an atmosphere of the vapor of the metal to be alloyed or deposited thereon, said metal being in a molten state, and passing hydrogen gas through or over the molten metal.

911,140. Leather Product and Process for Making the Same. Hugh Mackay, February 2, 1909.

The process consists in surface hardening sole leather by soaking the same in an aqueous mixture of Portland cement and borax.

911,254. Ammonio-Cyanide Process of Treating Ores Containing Precious Metals. Davis Mosher, February 2, 1909.

The process consists in treating copper, nickel, zinc and cobalt ores and tailings with gold and silver values, by simultaneously extracting all the metals with a solution of ammonia, and an alkaline earth-metal cyanide.

911,269. Process of Producing Certain Proteids from Buttermilk. Ludwig H. Reuter, February 2, 1909.

The process consists in treating buttermilk by neutralizing the acid thereof at a low temperature, then moderately heating for a considerable period of time, then heating for a short time almost to the boiling point, thereafter cooling and filtering and subsequently precipitating the casein.

911,283. Process of Making Complete Fertilizers. John R. Young, February 2, 1909.

The process consists in decomposing by strong sulphuric acid, tri-calcium phosphate together with undried press-cake of nitrogenous organic matter and potash containing vegetable matter.

911,553. Process for Purifying Crude Petroleum and Its Distillates. Lazar Edeleanu. February 2, 1909.

The process consists in refining petroleum by introducing gaseous sulphur dioxide into the material to be treated in sufficient quantity to dissolve the constituents to be removed, reducing the sulphur dioxide to a liquid state whereby the constituents will dissolve therein, and separating the resulting liquids.

911,606. Surface Finish. Percy Neymann. February 9, 1909.

The composition consists of wax, a solvent, coloring matter, and an ingredient for hardening the superficial wax composed of flowers of sulphur, butter of antimony, and acetic acid.

911,695. Process of Making Borax. Gilbert E. Bailey. February 9, 1909.

The process consists in manufacturing borax direct from a borate of a metal capable of forming an insoluble sulphate by roasting said borate with sodium sulphate, leaching the roasted product and separating the dissolved borax from the leaching liquor.

911,735. Process of Making Sulphur Dioxide. Chester W. Lyman. February 9, 1909.

The process consists in melting the sulphur, delivering it into a closed chamber, atomizing the sulphur at the instant of entering the chamber, and burning the atomized sulphur in the presence of a sufficient quantity of air to supply the requisite amount of oxygen for the desired compound.

911,832. Process for Producing Pigments. Ansil Moffatt. February 9, 1909.

The process consists in producing a white pigment composed of co-precipitated barium sulphate and zinc oxide by adding to a mixture of calcium oxide in water, barium chloride and zinc sulphate consecutively in quan-

ties equivalent to the calcium oxide dissolved, then allowing the water to resaturate with calcium oxide and continuing the operation.

- 911,928. *Composition for Preventing Scale in Boilers*. George Wegener. February 9, 1909.

The composition consists of water, terra-cutch, tannin, quercetin, and borax.

- 911,960. *Composition for Treating Fuel*. Edward H. Ellis. February 9, 1909.

The fuel-treating composition comprises potassium chlorate, sal-ammoniac or its equivalent, oxalic acid, and sodium chloride.

- 912,245. *Solder for Incandescent-Lamp Filaments*. Hans Kuzel. February 9, 1909.

This means of connecting incandescent lamp filaments to their supply wires comprises a solder containing carbide of tungsten.

- 912,266. *Hydraulic Cement*. Arthur C. Spencer and Edwin C. Eckel. February 9, 1909.

The cement mixture is made of natural iron silicate and other cement-forming materials.

- 912,298. *Process of Melting Pig-Iron and Steel*. Holden A. Evans. February 16, 1909.

The process consists in causing the hottest part of a flame to play on the metal, while its oxidizing parts play above said metal, and in collecting the molten metal while causing the same to be maintained in its fluid condition by a cooler portion of said flame.

- 912,509. *Process of Manufacturing Gas*. Bernhard Thiemich. February 16, 1909.

The process consists in producing gas from pulverized coal for actuating internal combustion engines by causing the coal to fall intermittently in measured quantities on to a heated surface, heating said surface, pressing the coal against this surface, and removing the residue, after the separation of the gas, before a fresh charge of coal is supplied.

- 912,540. *Pyrite Smelting*. James T. Carrick. February 16, 1909.

The process consists in producing in the furnace at the base of the focus region of slag formation, a restricted zone having a temperature higher than that of the rest of the furnace by injecting combustible at the point and effecting its combustion within the furnace.

- 912,568. *Method of Roasting Ores*. Henry K. Hess. February 16, 1909.

The method consists in placing the ores in a series of comparatively shallow receptacles of heat resisting material and arranging said ore containing receptacles in horizontal tiers one upon the other within a heating chamber, the receptacles of each tier breaking joints with those of the adjacent tiers, and heating the ore containing receptacles in said chamber.

- 912,622. *Manufacture of Hydrated Sodium Carbonate*. William E. Ridenour. February 16, 1909.

The process consists in intimately mixing definite proportions of water and sodium carbonate without dissolving sodium carbonate, the water used being limited to an amount insufficient to effect the crystallization of the product.

- 912,744. *Process of Recovering Sulphur from Sulphur-Bearing Gases*. Paul S. Smith. February 16, 1909.

The process consists in successively manufacturing water-gas in a plurality of separate generators, leading the water-gas formed successively in the several generators and sulphur dioxide to a common point, and heating said mixed gases.

- 913,275. *Process of Detinning*. Harry M. Fernberger. February 23, 1909.

The method consists in subjecting tin, associated with a metal, the chloride of which is not soluble in carbon tetrachloride, to the action of chlorine and carbon tetrachloride, separating the solution of stannic chloride from the residue, and adding water in quantity sufficient to separate the stannic chloride from said solvent.

- 913,311. *Manufacture of New Stable Iodine Compounds of Fats*. Bruno R. Seifert. February 23, 1909.

The process consists in first preparing an iodizing reagent by the admixture of solutions of iodine and iodic acid, mixing therewith at an elevated temperature cocoa-butter, permitting the mixture to stratify to separate the iodized cocoa-butter.

- 913,324. *Manufacture of Silicon Carbide*. Frank J. Tone. February 23, 1909.

The process consists in heating a porous mass of crystalline silicon carbide in proximity to commingled vapors of substances containing carbon and silicon to a temperature sufficient to cause the carbon and silicon to combine throughout the pores of the silicon carbide mass.

- 913,405. *Method of Extracting Iron*. Carl G. P. de Laval. February 23, 1909.

The method consists in extracting iron from a pulverized charge by introducing said pulverized charge continually in the upper part of a vertical shaft, heated from the outside and subjecting the charge to the influence of the centrifugal force in said shaft, so as to be thrown towards the wall of the shaft.

- 913,430. *Method of Precipitating Metals Electrolytically*. Arthur Ramen. February 23, 1909.

The process comprises electrolyzing a solution containing readily electrolyzable metals while maintaining a solution of ferrous salts, substantially free of such metals, about the anode of the electrolytic cell.

- 913,535. *Metallurgical Process*. George Moore. February 23, 1909.

The process consists in separating metals from their ores by volatilizing salts of the metal in a suitable vessel, forcing a condensable gaseous vehicle through the subjected ores, and condensing the impregnated vehicle.

- 913,606. *Boiler Compound*. Harry R. Young. February 23, 1909.

The boiler compound comprises a comparatively large quantity of powdered soapstone, a comparatively small quantity of an alkali, and a much smaller quantity of brown sugar.

- 913,653. *Process of Manufacturing Nitroglycerine*. Franz Aigner. February 23, 1909.

The process consists in nitrating a quantity of glycerin with a suitable quantity of a fresh mixture of concentrated nitric and sulphuric acids, separating the resultant tri-nitro-glycerin from the partially exhausted acids, containing less highly nitrated derivatives of glycerin, adding a suitable quantity of fresh concentrated nitric and sulphuric acids to restore the acid mixture to substantially its original percentage content of nitric acid, sulphuric acid and water, and nitrating a second portion of glycerin with said acid mixture.

- 913,657. *Solution for Treatment of Iron or Steel*. Albert Hayes. February 23, 1909.

The solution comprises chloride of ammonium and hippuric acid.

The Chemical Engineer

PUBLISHED BY

The Chemical Engineer Publishing Co., 355 Dearborn St., Chicago

Vol. IX.

MAY, 1909.

No. 5.

DESCRIPTION OF THE ALLENTOWN PORTLAND CEMENT COMPANY'S PLANT.

The new plant of the above company is located at Evansville, Pa., about 12 miles north of Reading, directly on the Schuylkill & Lehigh division of the Reading Railroad. Maiden Creek, an excellent stream of water, flows directly alongside the property, which latter consists of 140 acres of cement rock and limestone deposits.

The plant will when fully completed have a total capacity of 5,000 bbls. per day, and will be built in two sections, the first of which is now under construction. The first section will be erected for a capacity of 2,500 barrels per day.

The plant in general is located in a valley to the east of the Reading Railway, alongside of an immense body of cement rock, which latter has been thoroughly tested by drilling to 100 ft. and over, samples being analyzed every 10 ft. Running down through the middle of the plant is a creek, the result of a large spring located directly on the property, which bubbles right out of the ground. This spring, even during the dryest season, has a normal flow of about 750 gallons per minute. The plant is an electrically driven one; the power house being located to the west of the Reading tracks, between these and the Maiden Creek, a 50 ft. stream. The location is ideal, both as to water for condensing purposes and convenience for receiving fuel from the railroad; at the same time, it is not far from the plant, the center of distribution being about 900 ft. from the power house.

QUARRY EQUIPMENT, STONE STORAGE AND DRYERS.

The stone crushing house is located directly back of the kiln building, and the equipment consists of one No. 10 and three No. 6½ Lehigh gyratory crushers, with the necessary conveyors and elevators. All are driven by one large motor.

The quarry is located directly back of these crushers. The cars, each having a capacity of 75 cu. ft. will be loaded with a steam shovel, pulled up an incline by means of a motor driven hoisting engine, and discharged into the large No. 10 crusher. The No. 10 crusher takes the large stones and reduces them to 1½" to 6". The material from this crusher discharges into a large elevator, which distributes the material

into two No. 6½ gyratory crushers on cement rock, where the material is crushed so as to give a product which will pass through a 2" to 2½" ring. The other No. 6½ crusher is used for limestone, which is of course crushed separately. The crushed material is then carried by elevators and discharged onto conveyors which carry the material into the large bins over the dryers. These latter are located directly back of the kilns.

The bins over the dryers have a capacity of 12 hours' run. There is also, between the stone crushing house and the dryer department, a large storage bin with tunnels underneath, giving about 24 hours' run for the dryer department. So that, even should anything serious happen in the quarry by reason of storms, etc., there would be a 36 hours' run for these dryers before they would get out of material and before it would be necessary for the kilns to operate direct, as will be explained later. The storage bins over the dryers have automatic shaking feeds underneath them, giving a constant flow of material to the dryers.

The stone dryers are three in number for cement-rock and one for limestone. They are of the Matcham type and are located directly back of the kilns, utilizing the waste heat from the kilns for drying the stone. The diameter of these dryers is large, so that there will be no serious effect upon the burning of the kilns which are working in conjunction with them due to their operation. The dryers are 7 ft. in diameter and 50 ft. long.

Leaving the dryers the material discharges into elevators, is lifted up and deposited upon belt conveyors which carry the dried stone, both cement-rock and limestone, to the stone storage. The stone storage will have a capacity of about 3,000 tons of cement-rock and 2,000 tons of limestone. The mixing will take place from the bins in the stone storage. At the bottom of the bins, there will be arranged hopper gates directly opposite each other, about 8 ft. centers. Two or three small cars, of about one cu. yd. capacity, each, having movable partitions running lengthwise and mounted on wheels, will be moved directly underneath a set of these hoppers. The partition in the cars is to be regulated according to the analyses of the different raw materials, so that as these cars are filled, first one side with limestone and then the other side with cement

rock, the mix will be uniform, and done by volume and not by weight. This method of mixing, in connection with these materials, is being successfully used by a large number of manufacturers in this district, that is, mixing the materials by volume before they go to the granulators. These cars after being filled, are arranged with drop bottoms, and discharge directly onto belt conveyors, these latter in turn into elevators, and the latter onto overhead belt conveyors, which carry the raw material direct to the bins over the ball mills in the raw department.

RAW DEPARTMENT.

The raw material department is laid out for the final unit of 5,000 bbls., but only the machinery for the first section of 2,500 bbls. is to be installed, and in this section there will be two No. 8 Krupp ball mills. These No. 8 Krupp ball mills are used for preparing the mixed raw materials for the Fuller mills. They are similar to the standard No. 8 Krupp ball mill, with the exception that there are no outside screens required, and there are 16 grinding plates in them instead of 12. These plates are perforated with $\frac{3}{4}$ " holes and are of such design that the foresieves are done away with, closing up the openings between the plates. One of the many advantages of this type of mill is that it practically protects the pulverizer machines against all chance of bolts, nuts, etc., getting to them, unless the latter have been ground down small enough to pass through these holes, when they will not give trouble. Then again, the uniformity of the material is assured, as all the material must pass through uniform size holes, and these, owing to the heavy chill on the grinding plates, remain constant in diameter, giving a uniform feed, which result cannot be readily obtained with other types of preliminary machines.

The material leaving these ball mills is discharged into elevators, lifted up and distributed in a large storage bin over the Fuller-Lehigh pulverizers by means of a paddle conveyor. This latter gives the material an additional mixing.

Flowing out of this bin, the material is fed to seven 42" Fuller-Lehigh pulverizers, which are by far the best pulverizers on the market, owing to the fact that they give the greatest percentage of impalpable powder in the finished product. They also give the greatest amount of output per horsepower. They have the lowest cost for repairs and repair parts do not require any machining, the latter being an advantage particularly appreciated by the operator. Also last, but not least, the initial cost of the installation of this particular type of mills is about 30% lower than any other type of pulverizers. By far the best mixture that can be obtained is obtained in these machines, owing principally to the method of their operation, and the discharge of the seven different mills into common conveyors, assures an absolute uniformity of mixture and fineness.

KILNS AND COOLERS.

Leaving the Fuller mills, the material is carried to a

large storage over the kilns, which is designed in one long continuous bin for the four kilns; this being the number of kilns to be installed in the first unit. This bin has a capacity of from 500 to 600 bbls. per day for each kiln, or 24 hours' run. The material is fed to the kilns by means of a screw conveyor which feeds into an inclined feed pipe leading directly into the kiln. This type of arrangement has been brought to the highest state of perfection and is adopted as the best method for feeding raw material to the kilns.

There will be four kilns in the first section. These kilns are 8 ft. in diameter and 120 ft. long. Each kiln has four tires, with a movable hood at the front end, and a large stack at the rear end. These stacks are of sufficient height and diameter to take care of a production in the neighborhood of 700 to 800 bbls. of clinker per kiln per day, and are also designed so that ample draft will be secured in order to successfully operate the Matcham natural draft system of coal burning, which is installed in connection with these kilns. Two kilns discharge into a common elevator, and from this into rotary coolers. There will be four coolers in all. There is a separate stack for each of these coolers, to create draft.

At the discharge end of the coolers, for about 3 ft., the shell is perforated with $1\frac{1}{4}$ " holes, making a rotary screen out of the end of coolers, and directly at the end is a large angle iron with the flange turned in so as to hold inside of the coolers any large lumps of clinker until they can be removed by an attendant, or gradually broken up by the revolving action of the coolers. Directly under this screen is a belt conveyor which leads to an elevator. The clinker which has been broken up from lump-form can easily be fed by an attendant into this belt, so that all the material goes directly to the elevator and then, by means of belt conveyors, to the clinker storage. The conveyor has a movable tripper, so that it may be dumped at any point.

CLINKER DEPARTMENT, STOCK HOUSE, ETC.

Directly under the clinker storage will be arranged a tunnel for drawing the clinker onto a belt conveyor, carrying the clinker to the gypsum house, where a certain percentage of gypsum is added. The mixture is then lifted up, discharged into a rotary screen, with $\frac{3}{4}$ " holes. The fine product from this goes directly to the eleven Fuller-Lehigh finishing mills, and the coarse is fed to a No. 8 Krupp ball mill, without screens, the product from which discharges into the same elevator that delivers the material to the finishing mills.

The finishing mills are fed with material which will pass through a $\frac{3}{4}$ " mesh screen, or practically $\frac{1}{2}$ " and under. Between the rows of finishing mills are arranged two conveyors, discharging into a common elevator, which lifts the cement up and discharges it into a screw conveyor which takes the cement to the stock house. The cement is discharged into the bins of the stock house by means of a long screw conveyor. The packing house is arranged so that the stock house can

be doubled in capacity as the plant grows, and the same packing house used for both stock houses.

There are three passageways running between the bins, the full length of the stock house. In these screw conveyors are arranged for carrying the material from the bins to the packing house. The stock house is divided into a number of bins so that the cement can be held for long-time tests, if necessary. The Bates valve bag machines will be used for packing the cement.

COAL MILL.

The coal is brought from a hopper below the tracks and carried by means of an elevating and conveying system to the top of the coal storage, the capacity of which is ample for a plant of 2,500 bbls. per day and upward. A large percentage of the material is fed by gravity into a set of rolls in the pit, which crushes down the large lumps, and discharges them into the elevator, which lifts up the coal and discharges the same into two dryers of the Matcham type. These dryers are being adopted universally by the plants in this district, as being the most economical, as well as the safest dryer now made. This dryer consists of a long shell, about $4\frac{1}{2}$ ft. by 30 ft. long, with a furnace built around same. The gases pass around the shell of the dryer, through the flue to the discharge and are sucked through the dryer and out of the stack at the back end. The temperature of the gases being so reduced by the time they flow into the discharge end of the dryer, that there is no danger of the coal catching fire. These two dryers discharge into an elevator, which lifts the coal up and discharges it directly into a bin over the pulverizers. Any pieces of iron in the coal are separated from the latter by magnets.

The two coal pulverizers are of the same type as those used for the raw material and clinker, that is, 42" Fuller-Lehigh mills. They discharge into a screw conveyor, from which the pulverized coal is lifted by means of an elevator to a screw conveyor passing over the bins directly in front of the kilns. It is only necessary to watch the last coal bin in front of the kilns, for if that one is kept full constantly, the balance of them will always be full, for the reason that there are openings in the bottom of the conveyor passing over these various bins, which are covered, so that when the last bin is full all the others have to be.

POWER PLANT (ENGINE ROOM AND BOILER HOUSE).

As mentioned before, the Allentown Portland Cement Company's plant is an electrically driven one throughout, and the power house is located about 900 ft. to 1,000 ft. from the plant.

There will be three large Wetherill cross-compound condensing engines, direct connected to large AC generators, in the engine room. There will be also in this department one relay unit for break-down service; one large motor generator set, and an engine driven exciter for break-down service. There will be a large switch-board for operating the various circuits, while overhead, for the installation of machinery and for making general repairs, there will be a 10-ton traveling crane.

In the boiler house there will be five 400 h. p. Rust vertical tubular boilers, each boiler being fired by means of an improved stoker, namely, the Lehigh stoker. The Lehigh stoker is one of the latest developments in the stoker line. The handling of the coal to the boilers will be as follows: There will be located alongside of the power house a trestle, beneath which there will be a hopper, into which the cars will be discharged. The coal dropping into this hopper will be lifted, by means of an elevator, to the top of the boilers and discharged onto a scraper conveyor, which will distribute the coal into the long continuous bin in front of the boilers above the stokers.

There will be two outside packed boiler feed pumps, with an open heater of the Cochran type. The condensing system will consist of an upright barometric condenser, of the Mesta type, with two independent circulating pumps and one dry pump.

MACHINE SHOP.

There is to be a machine shop in connection with this installation, fully equipped with lathes, planers, drill presses, shapers, boring machines and all tools necessary for making general repairs in connection with the type of machinery installed in this plant.

BUILDINGS.

The buildings are constructed according to the most modern and up-to-date cement engineering practice. The stone storage, stone crushing house, raw mill, clinker mill, power house (engine room and boiler house), kiln buildings, are all built with steel-frame construction, the sides being covered with expanded metal and plastered. The roofs of the boiler house and kiln building will be corrugated iron; the balance of the roofs will be matched flooring, covered with composition roofing.

The coal house will be of steel-frame construction, having 14-foot retaining walls around the storage, with heavy buttresses; the roof and sides will be covered with corrugated iron.

The stock house and packing house will also be of steel-frame construction with heavy retaining walls around the stock house. The sides of building will be of expanded metal, plastered, and the roof of matched flooring, with composition roofing.

The machine shop is a steel structure throughout; the sides of expanded metal, plastered, and the roof of matched flooring with composition roofing.

There will be very little wood, with the exception of the roofs above stated, so that the danger of fire is reduced to a minimum.

RESUME.

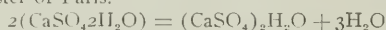
Taking the plant in general, the design is well adapted to the nature of the ground and every natural advantage has been utilized to make this plant the most economical plant in existence. The installation of a large steam shovel; the largest crusher in the Lehigh Valley; Fuller-Lehigh mills throughout; large storage bins in the various departments; an extra large storage of raw crushed material; large clinker storage; the

most economical way of burning and drying the material and various other improvements and up-to-date methods designed for reducing the cost of manufacture, should place this plant in a strong position.

THE MANUFACTURE OF PLASTER OF PARIS.

The quantity of plaster of Paris produced in the United States during 1907 amounted to 1,060,107 short tons, valued at \$4,211,821. The bulk of this plaster of Paris came from Iowa, Kansas, Michigan, New York, Ohio, Virginia, Oklahoma and Texas.

Plaster of Paris is made from gypsum by heating the latter to a temperature of between 212° and 400° F., when three-quarters of the water of crystallization of the gypsum is driven off, the resulting product being plaster of Paris.



In actual practice the temperatures employed to

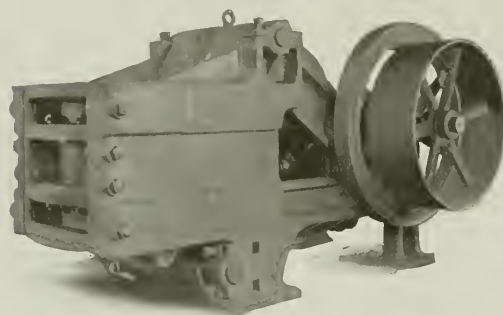


Fig. 1—Jaw Crusher or "Nipper" for Gypsum: Ehrsam & Sons Mfg. Co., Enterprise, Kan.

bring about this reaction are 330° to 395° F. If gypsum is heated above 400° F. it loses all of its water of combination and becomes anhydrous sulphate of lime, the latter being the basis of hard finish plaster, floor plaster, Keene's cement, etc.

When plaster of Paris is mixed with water it sets or hardens very promptly, this change being due to absorption of water, forming gypsum again.



A pure plaster of Paris will normally harden or set in from five to fifteen minutes after having been mixed with water. If the gypsum from which the plaster is made contains impurities, the set will be much slower than this. Plaster to be used for building purposes must be slow setting. For ornamental use, it must also be white, and since the impurities usually render the plaster slightly colored, it is the common practice to add retarders to the plaster before placing the same upon the market. The materials used as retarders are usually of a colloidal nature, such as glue, sawdust, blood, packing-house tankage, etc. If a very quick setting plaster is desired, crystallized salts are employed, such as common salt, sodium sulphate, sodium carbonate, etc.

Gypsum, the raw material from which plaster is made, is, when pure, a hydrous sulphate of lime, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. As mined, however, gypsum usually contains a considerable percentage of impurities, the chief of which being clay, calcium carbonate and magnesium carbonate. The following table gives the analyses of some American gypsum:

Locality.	Al_2O_3 $\text{SiO}_2, \text{Fe}_2\text{O}_3, \text{CaCO}_3, \text{MgCO}_3, \text{CaSO}_4, \text{H}_2\text{O}$					
Nova Scotia...	0.10	0.02	1.04	trace	78.60	20.13
Kansas	0.35	0.12	0.10	0.25	78.73	20.52
Michigan	1.24	0.50	2.38	....	77.19	19.03
Kansas	2.17	0.24	2.66	0.95	75.11	19.40
Oklahoma	17.95	1.43	....	....	61.00	18.44
Indian Terr...	10.67	0.60	10.21	1.10	59.46	16.59

Impure earthy gypsum, such as that shown in the last two analyses of the above table, is known in the trade as gypsum earth or *gypsite*. *Alabaster* is a pure white, fine grained, massive form of gypsum; while *selenite* is white, crystalline and almost transparent. Gypsum is a very soft mineral with a specific gravity of 2.30 to 2.33. The mineral anhydrite is closely related to gypsum and is anhydrous sulphate of lime. It is identical in composition with the product obtained when gypsum is heated until it loses all its water of crystallization.

Gypsum occurs usually in the form of beds, frequently associated with deposits of rock salt, and almost always inter-stratified with beds of limestone and shale. The beds, of course, vary greatly in extent and thickness, some of them being as thick as 60 feet, while a great many of them are very much smaller than this. The principal gypsum deposits found in this country lie in three geological series; namely, the Salina group of the Silurian, the Lower Carboniferous and the Permian. The localities in this country which produce gypsum are central and western New York, southwest Virginia, northern Ohio, Michigan and a great many of the Western states, Kansas and Oklahoma being large producers.

The usual plan of working the gypsum deposits is by mining, and deposits seldom lie near enough to the surface for quarrying. For the most part the mining methods are crude. Operations are usually started at the outcrop and follow the beds in. Main lines of haulage are run in as needed, and to the sides of these single rooms, more or less irregular in shape, are opened and worked. For the most part, the gypsum is blasted down by shooting it from the face or sides of the rooms. Some of the more improved plants operate tunneling machines and steam or electric drills, while at others small hand-operated post-augers are employed.

The operation of manufacturing plaster of Paris from gypsum consists in first crushing and grinding the gypsum, then calcining the ground product and finally pulverizing the calcined product, after which the retarders are added. In some plants, the gypsum is merely crushed and calcined, the calcined rock then being ground very finely. Where the kettle process

is employed, the pulverizing, however, is done before the calcining. Where the rotary cylinder process of calcining is used, the pulverizing is done after the calcining.

The process of preparing the gypsum for the kettles usually consists in first crushing it to such a size that it will pass a 2-in. screen. The crushers employed for this purpose are of both the Blake and the Gates types. Fig. 1 shows a crusher or "nipper" of the former type, especially devised for cracking gypsum. After the coarse crushers, the gypsum is further reduced by means of a double cone or pot crusher. These crack the gypsum to such a size that most of it will pass a

cast iron. A kettle with a sectional cast iron bottom, which, of course, facilitates repairs, has also been recently employed to advantage. The kettle itself, which is placed on the kettle bottom, is made of boiler iron, $\frac{3}{8}$ to $\frac{5}{8}$ in. thick. It is from 8 to 10 ft. in diameter and 6 to 8 ft. deep. A kettle of this size will hold from 7 to 12 tons of pulverized gypsum and produce from $5\frac{1}{2}$ to 10 tons of plaster. The kettle is provided with from two to four flues, 12 in. in diameter, placed horizontally about 8 in. above the crown of the kettle bottom and separated externally about 6 in. The kettle is surrounded by brick work so that the heated gas from the fire may rise around its sides and through

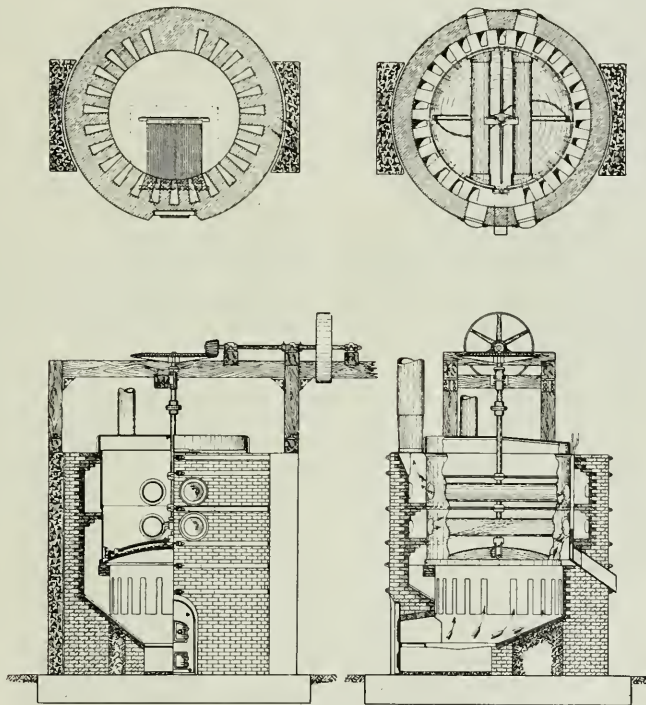


Fig. 2—Four-Flue Calcining Kettle; J. E. Ehsam & Sons Mfg. Co., Enterprise, Kan.

$\frac{1}{2}$ -in. ring screen. From the pot crusher the gypsum passes to buhrstones, rock-emery mills, Williams mills or Stedman disintegrators. These reduce the gypsum so that about 60% of it will pass a No. 100 mesh sieve. It is then ready to be fed to the kettles.

The gypsum kettle is shown in Fig. 2. This consists of a steel cylinder set in brick work. The bottom of the kettle is made of cast iron and is convex in shape. The bottom has a thickness of about $\frac{3}{4}$ in. at the edges and 4 in. at the crown. This kettle bottom is a very important part of the apparatus and is the part which seems to need oftenest repairing. If made from ordinary scrap iron they are apt to crack. Sheet steel has been tried, but does not seem to be as good as the

the flues. The top of the kettle is covered with sheet iron, has a movable door and a vent to carry off the water. The two kettles are usually placed side by side and work in pairs.

It is necessary that the material in the kettle be continually agitated. For this purpose the kettle is provided with a stirrer which is actuated by a vertical pinion wheel and a line shaft. The stirrer itself consists of a cross arm which is curved to conform to the bottom of the kettle and provided with either paddles or a chain which drags along the kettle bottom. The stirrer is run at about 15 to 20 revolutions per minute and is so arranged as to throw the material towards the center of the kettle. About 15 or 20 horsepower is

required to operate the stirrer. If the gypsum is not stirred the charge will settle down and become hard. The bottom would be also immediately melted out of the kettle. In starting a kettle the heat is gradually

F. is reached, when the material begins to boil and the water of combination begins to be driven off. An expert calciner can tell by the way in which the charge boils when the process is finished. When the material

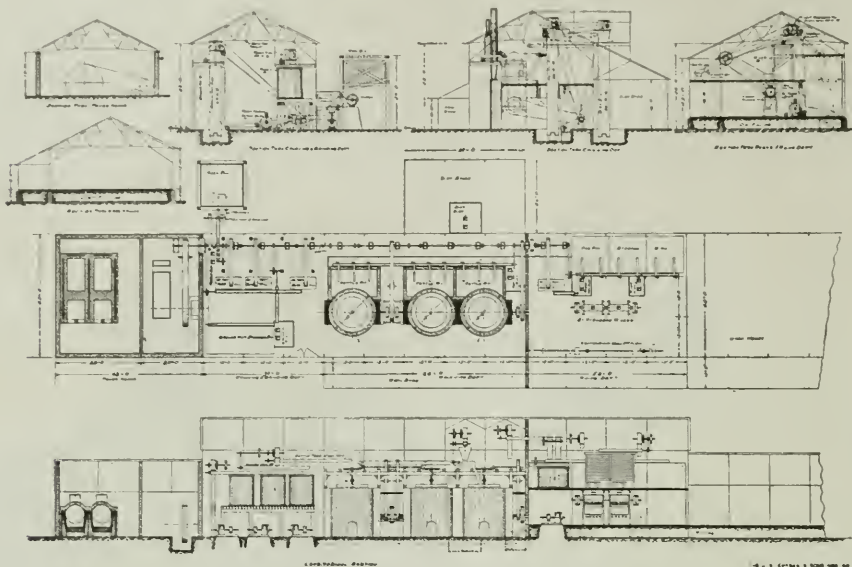


Fig. 3—Plan and Elevation of a Flue-Kettle Plaster Plant; J. B. Ehsam & Sons Mfg. Co., Enterprise, Kan.

applied, the crude material is fed in through the charging door and the stirrer put in motion. The material is added gradually until the kettle is full. As the temperature rises, the water begins to be driven off.

has been calcined sufficiently it is run by means of a small grate in the side of the kettle into a pit.

In burning pure gypsum the temperature rarely exceeds 340° F. Thermometers may here be used to ad-



Fig. 4—Blue Rapids, Kan., Plant No. 2 of the American Cement Plaster Co.

The mechanically held water is first driven off at a temperature of 212°, after which the contents of the kettle remain fairly quiet until a temperature of 290°

vantage. In gypsite plants, however, a higher temperature is required, which may sometimes reach as high as 390° F. Here, owing to the complexity of the

material, the proper temperature for calcining varies and thermometers can not be used.

The gypsum kettles are arranged in pairs with a pit to each pair of kettles in order that the pit may be emptied from one charge while the other is being cooked. The calcined material is carried from the pit, by means of an elevator, to a bolting reel, where the coarse material, usually amounting to only a few per cent, is screened out, sent back to buhrstones and re-ground. From the bolting reel the material is conveyed to a storage bin. There are usually several of these in order to separate the runs of different days.

The Cummert system of calcining consists in first partially crushing the material so that it will pass a one-inch ring screen. The gypsum crushed to this state is fed mechanically into a rotary dryer or calciner. The material, in passing through the calciner, is heated to a temperature of from 350° to 400° F., the exact temperature depending upon the nature of the rock. From the dryer the gypsum is carried into a storage bin. These bins are built of vitrified brick or concrete so that they will not take fire or absorb the moisture given off by the gypsum. Three bins are required for each calciner. These bins are also so constructed that the material is thoroughly ventilated. In these bins the calcining is completed, the moisture being driven off by the residual heat of the rock itself. After the gypsum has been partly dehydrated in these bins it is drawn out, crushed, ground, pulverized and bolted.

The retarder is added to the gypsum after this has been finely ground. Usually from 2 to 15 pounds of the former are required for every ton of plaster. The mixing is done in some form of a mechanical mixer. The Broughton mixer, Fig. 5, is extensively used for this purpose. An ordinary wall plaster will also contain in addition to a retarder a certain per cent of finely picked hair or other fiber, in the portion of about $1\frac{1}{2}$ to 3 pounds of hair to a ton of plaster. Wood fiber is sometimes added as a substitute for hair, and such use is growing. Figures 3 and 4 show the lay out plan and view of modern plaster plants.

Plaster is usually packed in jute sacks containing 100 pounds, or in paper bags containing 80 pounds. It is customary in the plaster trade, as in the cement trade, to charge for the jute sacks and give a rebate on the return of the latter. Where the plaster is packed in paper bags a charge is usually made for these latter.

Flooring plaster and hard finished plaster are also gypsum products made by burning this mineral until all of its water of crystallization is driven off. Flooring plasters are prepared by simply burning gypsum at a high temperature, while the hard finish plasters are produced by a double burning with the intermediate use of some chemical. Practically all of these plasters are imported. Flooring plasters are manufactured by burning pure gypsum, broken into lumps, in a vertical kiln. The kiln is heated by means of a grate, on one side of the kiln, upon which coal is fired. The hot

products of combustion pass through and so heat the gypsum in the kiln. The temperature reached is about 900° F. The time of burning is four hours. These floor plasters give a very hard and durable surface. They must be very carefully used to prevent cracking.

Of the hard plasters Keene's is the best known and was originally manufactured under an English patent. This, however, has long since expired. This cement is not only imported into this country but is also manufactured to some extent here. It is made by burning

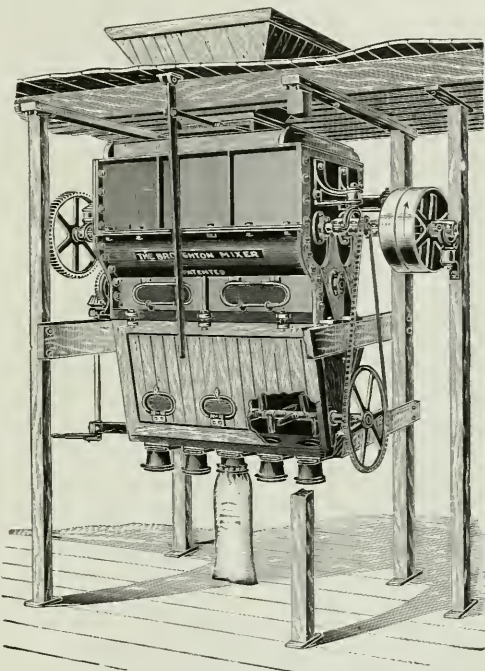


Fig. 5—The Broughton Mixer.

a very pure gypsum at a red heat. The resulting anhydrous calcium sulphate is immersed in a bath of alum solution and dried, after which it is again burned at a high temperature, finely ground and placed upon the market. It is necessary to employ a very pure gypsum as the slightest trace of iron would color the cement.

In a paper in *Cement Era*, Mr. H. H. Tiemann calculates that the loss of heat due to radiation from a rotary cement kiln, $7\frac{1}{2}$ ft. in diameter and 120 ft. long, amounts to 2.76 B. T. U. per square foot, per hour, per degree difference in temperature between the kiln shell and the outside air. Under ordinary conditions, this amounts to 1,722,600 B. T. U. per hour, or the equivalent of 133 pounds of coal per hour. Mr. Tiemann suggests that this loss be done away with by covering the kiln with some heat insulating substance, such as magnesia or asbestos.

THE PRESENT STATUS AND TECHNOLOGY OF THE PORTLAND CEMENT INDUSTRY.

At the present time, the Portland cement industry in the United States ranks second of the non-metallic industries in point of value, being exceeded only by the production of fuels—coal, oil and natural gas. Of the states Pennsylvania leads in production, the value of the cement manufactured by her mills exceeding that of the gold output of California or Alaska. Other large producers are New York, New Jersey, Ohio, Michigan, Kansas and California.

At the present time there are approximately 100 Portland cement companies in actual operation. There are also some 20 plants actively under construction. The number of incorporated companies is vastly larger. Some of these will probably at some future date succeed in financing their propositions and will then erect a mill. The larger number, however, will undoubtedly sooner or later cease to exist. The estimated capacity of the plants now in operation in this country is approximately 60,000,000 barrels annually, and of those now under construction 12,000,000 barrels more. At the end of 1909, the capacity of the plants at that time ready for operation should not be less than 70,000,000 barrels. The largest production of Portland cement so far recorded in this country was in 1907, when the output amounted to 48,785,390 barrels, valued at \$53,992,551. The output in 1908 was, however, only about 40,000,000 barrels, or some 18% less than the output in 1907, due, of course, to the financial depression of the country in 1908. The capital invested in the manufacture of Portland cement in the United States is certainly upwards of \$100,000,000.

Portland cement is manufactured at the present time from the following groups of materials: (1) Cement rock and limestone, from which approximately 41% of the Portland cement now manufactured in this country is made. (2) Limestone and clay, from which 47% is made. (3) Limestone and blast furnace slag, from which 4½% is made. (4) Marl and clay, from which 7½% is manufactured. The manufacture of Portland cement from cement rock and limestone is confined to a narrow belt in eastern Pennsylvania and western New Jersey. This belt extends from Reading, Pa., in a northeasterly direction to Martin's Creek, Pa., on the Delaware River. The deposit reappears on the other side of the river, some 15 miles lower down, at Alpha, New Jersey, and extends to Stewartville, New Jersey. The belt is bounded on the south by the Kittatiny limestone, which is high in magnesia, and on the north by the Hudson shales. The deposit is about 50 miles long and is nowhere more than four miles wide. The rock is an argillaceous limestone containing from 65 to 80% carbonate of lime and from 15 to 25% silica, oxide of iron and alumina taken together. The first successful Portland cement plant built in America was located

at Coplay, Pa., to manufacture cement from these materials. This section is still to be looked upon as the center of the industry, and the Atlas Portland Cement Co., located here, is the largest mill in the world. The manufacture of cement from limestone and clay or shale has increased very largely. The vast majority of the new plants are utilizing these materials, as they are much more widely distributed than any other. For the most part the limestone employed is of a very pure character and quite hard. Shale is now generally being preferred to clay for mixture with the limestone.

The manufacture of Portland cement from furnace slag and limestone is also largely on the increase, although it is being confined almost exclusively to the plants of the Universal Portland Cement Company. This concern now has mills in operation with a capacity of approximately 17,000 barrels of Portland cement per day. They have also another large plant of 6,000 barrels capacity under construction, which will make their total output 23,000 barrels per day. The mills are located at South Chicago, Ill., Buffington, Ind., and Pittsburg, Pa. These mills all secure their slag from the iron furnaces of the United States Steel Corporation, at these points. At their newer mills, the power is generated by gas engines driven by means of the waste gases from the blast furnaces of this corporation, the power being transmitted to the machinery electrically. The Universal Portland Cement Co. began the manufacture of Portland cement from limestone and slag about 1900. This cement is a straight Portland and is made by intimately mixing and pulverizing the granulated furnace slag with limestone, and then burning the product in rotary kilns heated by powdered coal.

A small plant in Michigan which attempted to manufacture cement from alkali waste (CaCO_3 from the causticizing of soda) and clay soon substituted limestone for the former. This was due to commercial reasons, however, rather than to any difficulty in the way of utilizing the by-product of the alkali plant.

Practically all of the cement manufactured in this country is made by the dry process, the exception being, of course, the small amount which is made from marl and clay and also some which is made by a few plants in the Kansas district. No new plants are at the present time being built for the manufacture of Portland cement from marl and clay, and indeed some of the plants recently built to use these materials have been changed over to dry process plants and limestone substituted for the marl. A few plants have also exhausted their marl beds and have been obliged either to bring in limestone or remain idle. The attempts to manufacture Portland cement from marl and clay by the dry process do not seem to have been successful, due, no doubt, to the fact that it is more economical to drive off the water from the marl in a rotary kiln than in a separate dryer; and also to the fact that the wet process offers much better facilities for making a

correct mixture of these two materials than does the dry one.

A so-called semi-wet process, in which the pulverized dry materials are moistened with water before being introduced into the kiln, is used at Iola and all of the United Kansas Portland Cement Co.'s plants. In this process, the mixture, when ready for the kiln, contains about 33½% water. The process has given satisfaction so far as the quality of the product is concerned, but this latter does not seem to be any better than that manufactured from the same materials by mills using the dry process. It is interesting in this connection to know that a process at the present time extensively used in Germany, in which the limestone and clay mixture is but slightly moistened with water and introduced into the kilns, was tried at some of the older mills in the Lehigh district and abandoned. The wet process unquestionably requires a great deal more coal than does the dry process and also the output per kiln is very much reduced. Most of the plants have found that the cheaper way of manufacturing a sound cement is to grind the raw materials very finely and thus do away with the necessity of the wet mixture.

The most approved method of mixing the raw materials at the present time employed in this country is unquestionably in the case of clay and limestone to do this after they have been partially reduced by either ball mills or some form of coarse grinder. It is then possible to not only sample the materials accurately, but the grinding has also served to mix and consequently to make the material more uniform.

At the plant of the Seaboard Portland Cement Co., Alsen, N. Y., being built by the Fuller Engineering Co., Allentown, Pa., one of the newest and best designed of the eastern plants, the limestone will be first crushed and then ground in ball mills with perforated screens. The limestone will pass from the ball mills into steel bins holding several hours' run. The contents of the steel bins will be analyzed as filled, and the clay will be added to the limestone in the proportion which the analysis shows necessary. The mixture will then be ground in Fuller-Lehigh mills. The clay will be dried and partially disintegrated before being mixed with the limestone. As the quantity of limestone analyzed in the bins is small, it is believed that it will be possible by this system to control the composition of the cement within very narrow limits. The weighing will be done by a pair of Richardson automatic scales, one of which will be used for the limestone and one for the clay, the charges from the two scales being dumped simultaneously and automatically.

Another excellent system of mixing the raw materials, which has been tried and proved satisfactory in this country, is to mix the raw materials before being crushed in such a manner that the composition is slightly higher in lime than is desired. This mixture is then passed through the ball mills and into steel bins holding several hours' run. The material is auto-

matically sampled as passed into the bins, and when the bin is filled, the sample is analyzed and the small amount of dried and ground shale or clay necessary to bring the mixture to the proper composition is then added.

With cement rock and limestone, however, much cruder systems of mixing will often give excellent results. With the lower grade (90% CaCO_3) limestones, even mixing by volume will produce a correct composition owing to the nearness in composition of the two materials.

The larger number of cement plants in this country dry their raw materials in rotary dryers, which are heated by a coal fire. These dryers, on such materials as cement rock and limestone, usually require about one pound of coal for every 6 to 8 pounds of water evaporated. The newer plants which are being built, however, will probably all of them utilize the waste heat from the rotary kilns to dry the material. This is being done at the plants of the Seaboard Portland Cement Co., at Alsen, N. Y., and the Allentown Portland Cement Co., at Evansville, Pa., where the Matcham system of utilizing the waste heat will be employed. This consists of a rotary dryer, which receives the heat direct from the kiln. These dryers will be 50 feet long and 7 feet in diameter. The lower end of the dryer fits into a movable housing, which can be rolled up against a brick flue into which latter the upper end of the rotary kiln projects. The idea of the movable housing is to allow entrance to the dryer if repairs are necessary. The kiln and dryer are both provided with stacks so that the kiln can be run independently of the dryer. It is possible by the use of these dryers to not only drive off all the moisture from the limestone, but also to heat the rock to a sufficiently high temperature to break down its structure and make it very much easier to grind. The rock drops from the dryers to an elevator and is carried by them into storage where it has a chance to cool.

In drying clay by this system, it has been found most efficient to dry the clay in two stages with an intermediate crushing. This has been found necessary owing to the fact that when the clay is run directly into the dryer it balls up, and the exterior serves to break up the balls, and a subsequent drying drives off the moisture that was contained inside of them.

In the grinding of both the raw material and the clinker considerable improvement has been made in this country in the last few years. The komminuter was introduced some 10 years ago and proved more efficient than the small ball mills, which were at that time used. An American firm, however, the Allis-Chalmers Co., of Chicago, soon afterwards brought out a very large ball mill, which proved also to be a more efficient machine than the smaller one. The Griffin mill was an American invention, a description of which is found in nearly all the standard works on the manufacture of Portland cement. The Fuller-Lehigh mill was brought out by the Lehigh Car. Wheel and Axle Works, Catasauqua, Pa., some four

years ago and the mill unquestionably represents the greatest development in the grinding machinery line made in this country since the beginning of the industry. The American cement manufacturer has taken very kindly indeed to the mill, and a large number of the older plants installed it, replacing in some instances tube mills and Griffin mills by Fuller-Lehigh mills. A majority of the new plants also have adopted it. Among these latter are the plants of the Seaboard Portland Cement Co., the Allentown Portland Cement Co., the Great Western Portland Cement Co., the Oklahoma Portland Cement Co., and the Ash Grove Portland Cement Co. These plants are equipped throughout with these mills, on coal, raw materials and clinker. In a test of these mills at the Ash Grove plant, made by the writer, the fineness of the raw material proved to be between 93 and 94% passing the No. 100 mesh sieve and between 83 and 84½% passing the No. 200 mesh sieve. The fineness of the cement in stock, amounting to 20,000 barrels, varied between 96 and 97% passing the 100 mesh sieve and between 85 and 87% passing the 200 mesh sieve. The tensile strength of this cement at the end of 7 days was 823 pounds neat; 342 pounds, 1:3 sand, and 234 pounds, 1:4 sand. These tests show the splendid results obtained with this mill at this point. A peculiarity of the product of this mill is the large amount of impalpable powder which the cement contains, and hence its great sand carrying capacity. The Fuller-Lehigh mill was fully described on page 34 of the February CHEMICAL ENGINEER.

In a recent comparative test made upon the same materials under the same conditions, the Fuller-Lehigh mill and a small pot crusher which was used to prepare the material for it ground 186 lbs. of material (pulverized 96½% through the No. 100 sieve) per h. p. hour against 115 lbs. of material ground (only 94½% through the No. 100 sieve) per h. p. hour by a komminuter and tube mill.

One of the objections to mills actuated by horizontal pulleys such as the Fuller-Lehigh mill and the Griffin mill has consisted in the necessity of driving them with a quarter twist belt. In the new mill of the Allentown Portland Cement Co., this is being done away with by the use of vertical motors to drive the Fuller mills. At the plants of the Universal Portland Cement Co., the Fuller-Lehigh mills in the coal grinding department are driven by means of these vertical motors. A great many of the newer mills have adopted the plan of driving their machinery by means of individual motors. A few of the western plants have been able to make use of cheap hydro-electric power in their grinding. In practically all cases, the power has been purchased from some large outside corporation developing water falls. Among the mills at which this has been done may be mentioned the Santa Cruz Portland Cement Co. and the Standard Portland Cement Co., both of California, and the Superior Portland Cement Co., of Baker, Washington. At some of the Kansas plants gas engines have been in-

stalled using natural gas for burning. At a few of the California plants crude oil is used for burning.

The air separators of the Peiffer type were given quite an extensive trial in this country some years ago, both placed after the tube mill, and also after the ball mill. In general it may be said that they have not proved satisfactory. While some few mills still use them, the majority of those who tried them have given them up. They have been used to some extent in connection with the Kent mill, where the need of an outside screen has made something of this sort necessary. Here they seem to have given as good satisfaction as the screen. The Kent Mill Co. has recently brought out a new mill, the "Maxicon," of the same general type as their older mill, the "Kent." These mills operate with either air or screen separators. The "Newaygo" seems to be the most popular of the latter, and is used in connection with the Kent mill at a number of places.

The Raymond Mill Co. has brought out a mill of the roller type in which an air separator is used. These mills are being installed in several mills for coal grinding in a rather novel manner. The grinding rolls or mill part are located on the ground and the separator above the coal bins for feeding the kiln burner. The coal is blown up into the separator, through a pipe, by means of a fan. Here the fine and coarse coal are separated. The latter returns to the mill for regrinding and the former falls into the bin. The object of this installation is, of course, to do away with elevators and conveyors.

It has been found that clinker which has been seasoned in the air sufficiently to absorb 2 or 3% of moisture and carbon dioxide, grinds very much easier than clinker fresh from the kilns. A number of mills in this country have taken advantage of this fact, and installed splendid systems for seasoning their clinker. One of the best of these arrangements is that of the Dexter Portland Cement Co., at Nazareth, Pa. This storage consists of a pan conveyor which is supported on a steel trestle and protected by a roof. The conveyor may be discharged at fixed points. The clinker is carried out and deposited underneath this conveyor in a long pile. It is allowed to remain here for two or three weeks, when it is drawn out by means of spouts onto belts in two underground tunnels, which run lengthwise under the clinker piles. No roof is placed over the clinker and consequently any rain which falls upon it helps to season it. Owing to the fact that in very rainy weather this clinker when drawn from the pile is wet, it was deemed advisable to install a dryer just before the grinding mills, but this dryer is only used occasionally when the clinker is very wet. The capacity of the storage is about 72,000 barrels of clinker. The clinker is drawn out of one end of the pile while it is being dropped into the other. The effect of the seasoning is also, of course, to improve the soundness and trowelling properties of the cement ground from this clinker.

Practically all of the cement now burned in this

country is burned in rotary kilns, and in place of the old kilns 6 ft. in diameter and 60 ft. long, practically all of the more modern cement plants have installed very much longer kilns. In some instances, this has been done by merely lengthening the old kilns; in other instances, the old kilns have served for the up-

air, but also allows a large portion of the air for combustion to be brought in with the coal, and the flame is also less hard upon the lining of the kiln. The system was first installed at one of the plants of the Lehigh Portland Cement Co. It will also be used at the new plants of the Allentown Portland Cement Co., and of the Seaboard Portland Cement Company.

Rotary coolers are gradually replacing the upright coolers so universally used in the Lehigh district. In most instances the air is drawn through these by the kiln draft and hence they serve not only to cool the clinker but also to preheat the air. As every pound of clinker carries out of the kiln between 450 and 700 B. T. U., it will be seen that this practice should save between 11 and 20 lbs. of coal per barrel of clinker.

Methods employed for bagging the cement have always been of the crudest kind. The Bates valve bags and machine for filling these have recently been given a trial in the cement industry and the system has proved very successful. It is being installed in a number of the new plants and many of the older ones also have adopted it after thoroughly trying it out. The system does away with many of the defects of the old methods of packing, including short and over weight, bags coming untied in transit, slowness of packing, need for skilled labor, etc.

As to the general condition of the product, it may be said that since the adoption of the standard specifications, most manufacturers have been content to rest with manufacturing a product which would safely

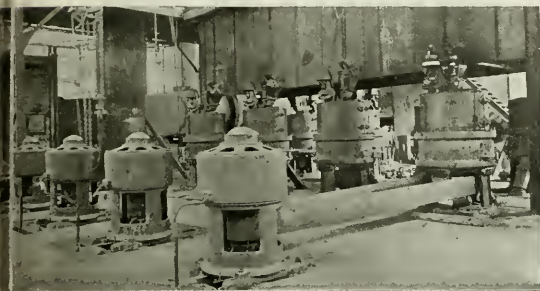


Fig. 1—Fuller Mills Driven by Vertical Motors at Plant of Universal Portland Cement Co.

per end of the new and longer kiln, another section of larger diameter being fastened to the old kiln by a tapering section, the new section serving as the clinkering zone. Where new kilns have been installed the practice has usually been to make them perfectly straight or at least to taper them only sufficiently to take care of the smaller size fire brick, which is used in the upper end of the kiln, and thus have a kiln of one inside diameter all the way through when lined with fire-brick. Of the cement plants now being built, all will have kilns 100 ft. or more in length and 7 ft. in diameter. Out of twelve of these, two will have kilns 8 x 150; two kilns, 8 x 125; two kilns, 7½ x 125; two kilns, 8 x 120; three, kilns 7 x 110, and one, kilns 8 x 100. At least half the kilns now in operation in this country are 100 or more feet in length.

The bottled rotary kiln, that is, a kiln with a clinkering zone very much larger in diameter than the rest of the kiln, was tried in this country in the early days of the industry. It can hardly be said, however, that it proved a commercial success. The output of these kilns is small and the coal consumption seems to exceed that of the straight diameter rotary. For the most part, the combustion in them is poor, due to the fact that the carbon dioxide liberated is not carried off fast enough. These long kilns are being made to bear upon from two to five tires (Edison's bear on many more).

The principal improvement in the burning of cement in this country has been in the invention by Mr. Chas. A. Matcham of a natural draft system of burning powdered coal. In this system, no fans are necessary and the coal is merely sucked into the kiln by the draft of the latter, which is increased by the use of slightly higher stacks. The arrangement for burning consists of a feeding device, which drops the coal across a slit in the hood of the kiln. The system not only does away with the use of fans for supplying



Fig. 2—Clinker Storage of the Dexter Portland Cement Co.

meet these. Some more enterprising ones, however, particularly in the less conservative West and Middle West, boldly advertise a product very much more finer than the standard requirements. The new Allentown Portland Cement Co. mill, being equipped with Fuller-Lehigh mills for pulverizing, will be able to produce commercially a very finely ground cement, and they announce their intention of producing a cement containing more impalpable powder and hence greater sand carrying capacity than has heretofore been done in the East.

As to the newer cements, plants have been started up in this country for the manufacture of snow white Portland cement by the Sandusky Portland Cement Co., at York, Pa., where a very complete mill has been built; by the Berkshire White Portland Cement Co., at Clayton, Mass.; by the Blanc Portland Cement Co., at Allentown, Pa., and by the Art Portland Cement Co., Kimmel, Ind. These cements are all manufactured from white clay and very pure limestones, both of which must be practically free from iron. They are burned in rotary kilns with oil or producer gas. The product of all of these plants contains less than $\frac{1}{2}\%$ iron, and they pass satisfactorily all the tests ordinarily

this country, and the writer questions whether engineers would not prefer to employ the old standard brands of Portland cement, which they have used and found when properly used satisfactory in sea-water construction, rather than risk new and untried material on important engineering work.

EFFECT OF TEMPERATURE ON CONCRETE.

The Aberthaw Construction Company, of Boston, Mass., has recently completed some interesting tests made to determine the relation of temperature to the time of set and strength of concrete. The most interesting point brought out by this investigation is the fact that at a temperature of 72° F. the cement showed a decrease in strength from the seven-day to the 28-day neat test, while on mortar tests the strength was the same. On the other hand the tests at 41° F. gave a good increase in strength between these periods for both sand and neat briquettes, and at 34° F. an even better percentage increase on both was obtained. This would seem to offer an argument against requiring an increase of strength between these periods, since no one for an instant would contend that concrete made at 34° was better than concrete made at 72° , although the former shows the better increase.

NEW CEMENT FOR SEA WATER.

Mr. J. C. Potter, an English chemist, described in a recent issue of the Journal of the Society of Chemical Industry, a cement which he had prepared for resisting sea-water. It is made by grinding six parts by weight of calcined red brick clay with ten parts of Portland cement. This product the inventor calls "red cement." Mr. Potter states that briquettes made from this cement, and also from ordinary Portland cement, immersed in sea-water for periods up to 10 years, show red cement to increase in strength while Portland cement decreases in strength when placed in sea-water. Over 5,000 tons of this red cement have already been used in sea-water, according to Mr. Potter, and the results are satisfactory.

The American Foundry & Machinery Co., manufacturer of the Swenson evaporator, leaching cells, diffusion batteries, heaters and other chemical machinery, has changed its name to the Swenson Evaporator Company. The office will be as before, at 944-5-6 Monadnock Block, Chicago. The new company has retained the same organization and Mr. F. M. de Beers, formerly manager of the American Foundry & Machinery Company, will continue in charge of the business.

The Electro-Mechanical Engineering Bureau has opened offices in the Monadnock Block, Chicago, Ill., for consultation, inspection and tests along mechanical, electrical and chemical lines.



Fig. 3—Method of Bagging Cement.

applied to Portland cement. The demand for them, however, has been much less than their excellence and beauty warrant, although architects are beginning to use them to some extent. They have brought prices ranging between \$8.00 and \$10.00 per barrel. Below will be found analyses and tests of the Sandusky White Portland cement:

Silica	23.56%
Iron oxide	.32
Alumina	5.66
Lime	64.12
Magnesia	1.54
Sulphur trioxide	1.50
Loss on ignition	2.92

Fineness through a No. 100 test sieve = 94.7%.

Fineness through a No. 200 test sieve = 76.9%.

Boiling test, 5 hours = Good.

Initial set = 3 hours and 45 minutes.

Final set = 6 hours and 30 minutes.

Tensile strength 1 day neat = 383 lbs.

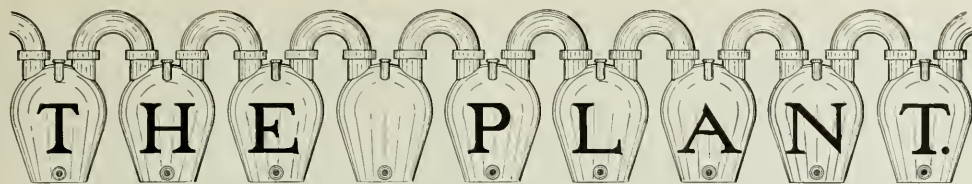
Tensile strength 7 days neat = 627 lbs.

Tensile strength 7 days sand = 213 lbs.

Tensile strength 28 days neat = 755 lbs.

Tensile strength 28 days sand = 246 lbs.

No attempt has been made in this country to date to manufacture an iron or sea-water cement. The proposal to do this has met with very little favor in



REINFORCED CONCRETE FOR CHEMICAL FACTORIES.

By J. P. H. PERRY.

Turner Construction Co., New York, N. Y.

Reinforced concrete has passed the age of experiment and has become an established structural material of recognized merit. This statement is true amongst engineers, contractors, and the building trade generally, but the executive heads of certain industries may have some skepticism in regard to the same. In fact, it is not unusual for the advocates of reinforced concrete construction to encounter questions as to its relative merits and possibilities. The more frequent queries which are received from architects and owners

face of it the cutting of concrete for the placing of machines or for such alterations as just outlined, seems difficult, in reality the mountain becomes a mole hill when seriously looked into.

It not infrequently occurs that the owner of a large chemical factory in deciding to put up a new building does not know to what extent the processes which he proposes to use in this structure will develop, and, therefore, he cannot be certain how large a building he may some day require. Consequently he wants a building which he can add to readily. As most chemical factories are one or two story affairs, these additions are generally made lateral, which entails ripping out walls. Under such conditions concrete for the walls is not to be recommended, as it is unquestion-



Fig. 1—Reinforced Concrete Factory Buildings, Keuffel & Esser Co., Hoboken, N. J.; Turner Construction Co., Engineers and Builders.

in the chemical industry are briefly these: Provision for piping and shafting; possibility of cutting through walls for the making of additions to the building; load carrying capacity; speed of erection; and, finally, cost.

If the position of piping and shafting is known previous to the erection of the proposed building it is an easy matter to set in the concrete at the time it is cast, hangers or sockets to which the transmission lines, wiring, steel pipes, water pipes, etc., can be attached. When, however, there is a possibility of there being alterations made in the layout of the piping, the problem is a little less easy. Generally this contingency is met by setting sufficient anchors or hangers in the concrete to allow of flexibility in the layout of the transmission lines. If this has not been done, however, the new piping can be secured by means of expansion bolts set in holes drilled in the sides of the concrete beams or girders or in the bottom of the slabs. This has been done in several large factories known to the writer with small cost and uniform success. Though on the

ably more difficult to remove than brick or terra cotta. The character of the structure which should be adopted, however, if the prospective builder desires a thoroughly modern, fireproof building, is a reinforced concrete skeleton consisting of columns, girders, beams, and floors, with the walls non-self-supporting and of minimum thickness. These walls, if made of brick or terra cotta, can then be easily removed without effecting the structural part of the building. This method of construction enables the designer to provide maximum light, which is an important factor in the efficiency of the employees in any factory.

In regard to the load carrying capacity of reinforced concrete buildings, there is little doubt in the minds of those familiar with the subject as to the supremacy of the material along this line. Reinforced concrete floors can be designed to carry practically any loads. As an instance of this, certain grain tanks in Buffalo may be cited where the floors are designed to carry a superficial load of 5,000 pounds per square foot. There

are a number of buildings in this country where the specified floor load runs 2,000 pounds per square foot, and buildings with floor loads of 500 and 600 pounds are very numerous. Reinforced concrete floors are considerably stronger than they are designed for. A factor of safety of four based on low ultimate

units immediately upon the removal of the old building and several floors erected before the arrival of the structural steel, which is the essential part of the rival class of construction. The writer is familiar with three instances of quick erection of reinforced concrete buildings which it may be worth citing. The Mason



Fig. 2—Three Model Factory, Bush Terminal Co., Brooklyn, N. Y.; Turner Construction Co., Engineers and Builders.

strengths is generally used, and experience shows that the average well built concrete building will sustain loads several times in excess of the theoretical concrete load, even taking account of the factor of safety. One case of this occurs in a large factory in Brooklyn where a 16-ton embossing press, resting on a base 3' x 6' (which is nearly one ton per square foot load), is carried by a floor designed to take only 250 pounds per square foot load. Of the numerous points which prospective builders raise in regard to this method of construction, its ability to carry loads is generally the simplest to answer.

A good many engineers and owners, when reinforced concrete construction is suggested to them, bring up the possible speed of erection. This is done in most instances with justification, as there have been buildings put up, where, owing to the inexperience or ignorance of the contractor, the time taken to complete the work was unduly long. With skillful organizations, of which there are several in this country, the average reinforced concrete building can be erected and completed at a speed which compares favorably with any other type of building. Particularly is this so when account is taken of the fact that in structural steel work the plans for the proposed building have to be detailed fully and the material ordered, rolled, fabricated, and shipped by the mills, whereas in reinforced concrete work can be begun on the footings and col-

building on Johnson Street, Brooklyn, is a seven-story and basement warehouse, 40 ft. by 80 ft. The time from the completion of the excavation to the day the roof was concreted was forty-eight working days. The Bush Model Factory No. 3, South Brooklyn, New York, is 600 ft. long, 75 ft. wide, six stories and basement in height. After the completion of the founda-



Fig. 3—Bergen Point Chemical Co., Warehouse; Reinforced Concrete Throughout; Turner Construction Co., Engineers and Builders.

tions the roof was put on in sixty-three working days. The Rogers & Pyatt Factory on Fletcher Street, New York City, is approximately 60 ft. by 70 ft. in plan, ten stories and basement in height. From the day the first concrete was placed in the basement columns to the finishing of the roof was forty-seven working days, and the building was turned over ready for occupancy in three and one-half calendar months. This speed of ten stories and basement in forty-seven working days

compares favorably with any other class of construction.

The final consideration in the selection of the type of construction for a new building is comparative cost. With respect to any other fireproof class of building reinforced concrete will show a saving of from 10 to 20%. In general practice the only other fireproof con-



Fig. 4—Cold Storage Plant, Eastern States Refrigerating Co., Hoboken, N. J.; Turner Construction Co., Engineers and Builders.

struction is structural steel protected with terra cotta or cinder concrete. There are numerous buildings which have been erected in reinforced concrete at a saving over actual bids received on the same set of plans executed in steel construction of 10, 15, 20, and even 25%. In actual dollars and cents there is a large warehouse in Brooklyn on which \$30,000 was saved by the adoption of reinforced concrete; a manufacturing building in Philadelphia where \$60,000 was saved by the architects considering an alternate bid in reinforced concrete construction instead of several figures already received for structural steel. Compared to first-class slow-burning mill construction at present market conditions, concrete will run from 5 to 10% higher in first cost. Where, however, the building is exceedingly large and six stories or more in height, concrete has been found to be about equal or slightly less in cost than the mill construction. Under ordinary conditions, however, the mill construction building is about 10% cheaper.

The first cost is not, however, the only item which should be considered before the type of construction is decided upon. There are a number of other facts, which, if valued, will total to a considerable annual charge. These briefly are as follows: Insurance; maintenance; depreciation; repairs to machinery, dependent upon the amount of vibration in the building; efficiency of employees in proportion to the amount of light and the sanitary conditions of the structure; water proofness, and vermin proofness. It is possible, by making comparative estimates of the value of these different items, to show that a reinforced concrete

building costing \$110,000, will save annually from 1 to 2% in fixed charges over a slow burning mill construction building at the initial cost of \$100,000.

A NEW BAG AND SYSTEM OF PACKING.

It is probable that every one who has visited the packing department of an establishment for the manufacture of lime, plaster of Paris, Portland cement, etc., has been struck with the crudeness of the methods which are used for bagging the material for shipment. In practically all of these establishments, the method of packing is simply to place a bag over a spout and opening a slot allow a quantity of material to flow into the bag. When the operator judges that the proper weight of material has run into the bag, the slot is closed, the bag is then removed from under the spout and placed upon a platform scale, where material is either added or taken from it until the proper weight is obtained. The bag is then lifted to a small bench, tied by hand, placed upon a truck, and wheeled by a laborer to the car or vessel. The whole operation requiring at least three men.

To the visitor who has been shown through a modern up-to-date plant, and has seen the material whirled along on automatic screw, belt and pan conveyors or shot up to the highest points of the building by bucket or platform elevators this seems indeed a crude method of bagging, and has the effect of making him believe that he has stepped from a century of subways and electric lights into the times of horse-cars and oil lamps.

A large amount of material is bagged in cloth bags

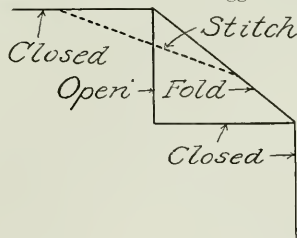


Fig. 1—Diagram of Bates Valve Bag.

or paper sacks. In the Portland cement industry alone, probably at least 175,000,000 cloth or paper bags are packed each year—practically all of them by the crude system mentioned above. This is done even in plants where the material is never touched by hand until it comes to be bagged. In many of these plants, the rock is blasted down by dynamite, thousands of tons at a shot. It is picked up by steam shovels and loaded into cars, which are pulled by means of endless ropes to the mill. Here it is conveyed from one stage of the process to the next by means of belt conveyors, bucket elevators and screw conveyors.

Need of an automatic system of bagging has long

been felt. The old and crude system has many disadvantages. The sudden splashing of the material from a spout into the bag often burst the latter by the shock of its fall. The time consumed in filling sacks by this method is also considerable and makes it difficult for mills to fill rush orders. Much loss by reason of over weight, due to carelessness, particularly when the workmen are rushed is always attended by



Fig. 2—Machine for Tying the Bags.

this system of bagging. The tying of the bags also presents a difficulty. Unless the bags are carefully closed, they are apt to come open in transit. With paper sacks and gritty materials the hands of the workmen suffer, largely due to the fact that the material sticks to the paper forming a good substitute for sand paper, which cuts into the hands. Workmen are very much averse therefore to bagging such materials as cement in paper sacks. The manufacturers on the other hand much prefer to ship in paper, as it is the usual practice where cloth bags are used to allow something when they are returned in good condition. There is always more or less friction between the manufacturer and the man who returns the bags as to just what good condition means, as to just how many were returned, and as to whether the bags were purchased from the manufacturer or his competitor, etc. With paper, on the other hand, the manufacturer sells the package also and hence is through as soon as the cement is shipped.

A new system of automatic bagging has recently been introduced which has already gained considerable headway in the cement and salt industries and which promises to revolutionize the methods of shipping material in our larger manufactures. The system is the invention of Adelmor M. Bates, who has for the past six years been experimenting with methods for rapidly and accurately bagging material. This system primarily depends upon a novel bag, of which the fundamental feature is a valve in one corner. This valve projects into the bag as is shown in figure 1. It is made by ripping and tearing down a corner of the bag and sewing up on the dotted line shown in the figure. When pressure is applied to the valve, as when the cement comes against it, the valve closes.

With this bag, the operation of filling which ordi-

narily consists of putting the material in the bag and then tying it, is reversed and instead, the bag is first tied and then filled, the filling being done through the valve by means of a special bagging machine which will be described a little further on in this article. When paper sacks are used, these are closed at both ends in the bag factory, where the valve is also placed in the bag by folding and pasting. The cloth bags are tied on a special machine which is capable of handling 25 bags at once. This machine is shown in Fig. 2.

With this appliance a boy can tie between four and five thousand bags in a day of ten hours. The tying is also done much more thoroughly than is usually the case by hand. A large amount of string is also saved. It is estimated by one large factory that the string alone saved amounted to more than the cost of tying the bags. As showing the security with which this machine ties bags we are informed that a recent shipment made from one of the large mills of the Lehigh Valley district, in Pennsylvania, to Portland, Me., only one sack out of 8,256 became untied. This is unusual, owing to the fact that this material was transferred at Jersey City from the railroad cars to the barge, and in this extra handling it usually happens that a great many bags become untied. The paper sacks, as we have said, are closed at both ends by paste. When full this package has both of its ends square and not only presents a neat appearance but also allows very close packing. Heavy paper sacks are very hard to tie owing to the stiffness of the paper. Where both the bag ends are closed, by paste in the factory, therefore, much heavier paper can be used. Consequently when material is packed by Mr.



Fig. 3—Bates Automatic Bagging Machine, Bates Valve-Bag Co.

Bates' system it is possible to use very much heavier paper bags than can be done where hand tying is resorted to.

To fill the bag the operator has only to throw the

self-closing valve of the finished bag over the top of the bagging machine (Fig. 3). This he can do with a quick one-hand motion. A lever is then opened which permits the material to flow into the bag. The material flows into the bag in a thin stream about one inch in diameter, and consequently there is no danger of tearing or ripping the bag. When the exact quantity of cement has been fed into the sack, the weight of the bag and contents off-sets a counterpoise at the opposite end of an evenly balanced beam. The bag, of course, begins to fall and simultaneously with this, the flow of

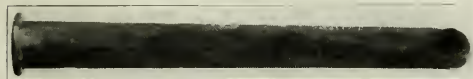


Fig. 4—Sampling Tube for Drawing Samples from Valve Bags.

material is shut off. The bag has only to move one-eighth of an inch for this to take place. It is consequently possible to make a very nice adjustment of the weight by this means.

In a recent test of 100 bags made at the plant of the Bonner Portland Cement Co., Bonner Springs, Kansas, 100 bags were filled by this machine and then weighed without the knowledge of the packing department. It was found that 26 per cent of the bags weighed exactly 95 pounds, 35 bags weighed within $\frac{1}{4}$ pound of the correct weight, 25 bags weighed within $\frac{1}{2}$ pound, 10 bags weighed within 1 pound and only 4 bags were further away from the correct weight than one pound. The total 100 bags weighed within 8 pounds of the total correct weight for 100 bags, namely, 9,500 pounds.

When the bag has been filled it is left hanging suspended by the valve spout in a position breast high to a man. From this point it is easily tilted down to the truck without the weight of the bag being felt unduly on the muscles of the men's arms. The men can consequently do a great deal more packing with this machine without fatigue than is possible by the older system. The value of this will often be felt during rush seasons. The men can work longer hours than would be the case with the old style packers.

The bagging machine may also be obtained mounted on wheels and carrying its own motor so that it can be employed to bag material which is stocked upon the floors and in bins not provided with conveyors. This machine is provided with horizontal conveyors which work against the base of the pile and scrape the material to an elevator which carries it up to a bin above the spouts. When it is desired to pack from a pile the machine has merely to be pushed with its conveyor against the material and the motor started. The automatic conveyors of the machine then elevate the material from the pile to the bin of the machine and in order to have a constant supply for bagging it is merely necessary to keep the machine pushed against the pile.

One of the greatest advantages of the valve bag is

the ease with which samples may be drawn from a shipment of cement. For this purpose a small brass tube (Fig. 4) is provided. This is simply thrust into the bag through the valve of the latter and the cement which it retains is withdrawn for sampling. The excellency of this device and the speed with which the sampling can be done, makes it possible to sample a large number of bags in the time formerly occupied in cutting and tying one or two.

AIR A CAUSE OF BOILER CORROSION.

Air will cause corrosion in boilers. Many cases of rapid corrosion have been proved to have been caused by the feed pumps sucking air from the feed hot-well. Small bubbles of air expelled from the water on boiling attach themselves fast to the heating surfaces. The oxygen in the air at once begins to act on the iron and steel, and forms iron rust, making a thin crust which, when washed away by the circulation by expansion and contraction, leaves beneath a small hole or pit, and pitting once started progresses rapidly. To prevent the air from entering the boiler the hot-well water should be pumped to a filter tank 8 ft. to 10 ft. above the feed-pump suction valves. By so doing a large amount of air rises and is liberated from the surface of the water, and a head of water at the suction valves of the pump is assured.

BIG KILNS.

It is stated that the Atlas Portland Cement Company are installing at their new plant, at Hannibal, Missouri, two kilns 12 ft. in diameter and 232 ft. long. These mammoth kilns will be far longer than anything ever built before. The Atlas Company, however, had in operation at one of their Lehigh Valley mills a kiln 12 ft. in diameter and 100 ft. long. These huge new kilns are expected to turn out at least 2,000 barrels of cement per day each. Their success will be watched with great interest by other cement manufacturers.

The Great Western Cement Plant, at Mildred, Kansas, has been started up, and the mill is now running night and day. About 100 men are on the pay roll and a small town has sprung up around the plant. The mill has a capacity of 2,000 barrels per day. The raw materials employed are limestone and shale, and the kilns are 8 ft. in diameter and 125 ft. long. Oil is used for burning, and the dry process is employed. Both grinding departments of the mill are equipped with Fuller-Lehigh Pulverizers. The plant is one of the most modern in the Middle West.

Recently some natural cement concrete work in the harbor at Brest, France, was removed. This concrete had been covered with sea-water for 100 years. Iron bars embedded in the concrete did not show the least indication of rust, showing that concrete is a perfect preservative of iron, even when placed under sea-water.

THE LABORATORY.

FREE LIME IN PORTLAND CEMENT.

Prof. Alfred H. White, of the University of Michigan, proposes the following tests for free lime in Portland cement in the January number of the *Journal of Industrial and Engineering Chemistry*. His method is based on the formation on the slide of the microscope of a characteristic crystalline calcium phenolate readily recognizable in polarized light. The reagent is prepared by dissolving crystallized phenol in an immiscible and rather non-volatile solvent and adding a trace of water. The method of preparation preferred by the author is to dissolve 5 g. of phenol in 5 cc. nitrobenzol and add to this solution two drops of water. Instead of nitrobenzol, alpha brom-naphtha-

a quarter of an hour develop into brilliant clusters of radiating needles as shown in Fig. 1 which is a photomicrograph of a commercial cement. On account of the great contrast in illumination between the brilliantly refracting calcium phenolate and the feebly refracting cement the photomicrograph shows nothing but the calcium phenolate crystals and does not show these sharply since their strong double refraction makes them appear to be surrounded by a halo. The eye of the observer at the microscope can readily discern the individual crystals forming what are only blotches of white in the photograph. If the lime fragments are crowded too closely together on the slide the crystals interlace so that their structure cannot be

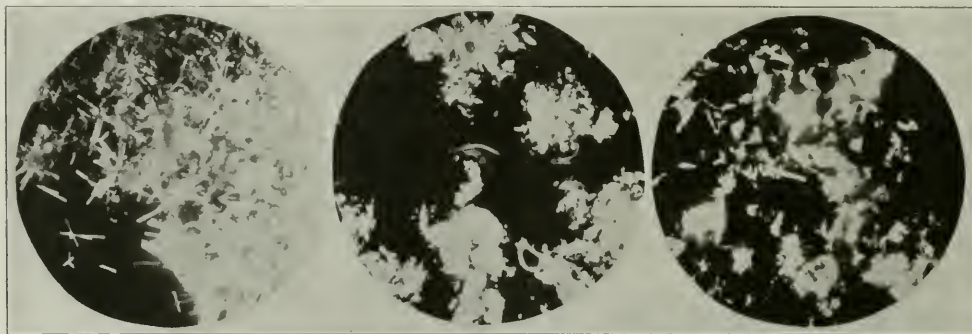


Fig. 1.

Fig. 2.

Fig. 3.

lene may be used, and is for some reasons, notably its lower volatility, to be preferred. It does not, however, give such sharp results as nitrobenzol.

In making this test about two or three milligrams of the finely powdered material are placed in the center of a microscope slide, a drop of reagent put upon it and then a cover glass, which is pressed down and rubbed gently to and fro till the cement spreads itself out somewhat. It is advisable not to spread the cement out too thinly but to leave a thick nucleus where the crystals will first appear, and to have the thickness decrease toward the edges. The slide is now observed in a polarizing microscope with the nicols crossed, or if easier for the eye, with the polarizer rotated slightly. The author usually used a two-thirds inch objective and one inch eye-piece giving a magnification of about 80.

The phenomena appearing when pure lime alone is being observed will first be described. When the freshly-prepared slide is put on the microscope the lime being isotropic is almost invisible and the whole field is dark. Within a few minutes the edges of the fragments of lime begin to show brilliant points which in

noted. These crystals grow till in the course of a couple of hours they may be 0.1 mm. long. Very little further change is noticeable for six hours, but in twenty-four hours the nitrobenzol will have largely evaporated and the crystals may have entirely disappeared. Confusion from formation of crystals of phenol has never been observed by us, the moisture present in the reagent or absorbed from the air probably preventing the phenol from crystallizing when the solvent evaporates.

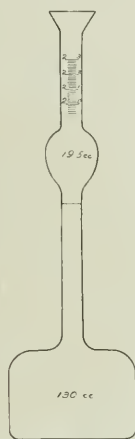
Hydrated calcium oxide gives needles similar to the oxide, but they generally form more rapidly and are finer. On the other hand, the crystals formed from lime which has been fused in the electric arc have a different form. Instead of straight needles the crystals appear as plumes or feathery petals which in favorable cases give the group somewhat the appearance of a chrysanthemum. Something of this appears in Fig. 2 where the dark nucleus in the upper group shows the granule of free lime from which the plume-like crystals grow. No substance other than calcium oxide or hydroxide has been found to give this reaction.

AN IMPROVED LE CHATELIER SPECIFIC GRAVITY BOTTLE.

By RICHARD K. MEADE

Director Meade Testing Laboratories, Nazareth, Pa.

The accompanying illustration shows a new specific gravity bottle which the writer recently designed and which is manufactured by the Carbondale Instrument Co., Carbondale, Pa. This specific gravity bottle is a new form of Le Chatelier's well known apparatus. Its peculiar features are that the small bulb is made pear shape. This allows the cement to drop naturally into the lower bulb and prevents the stopping up of the flask at the lower part of the small bulb, which often happens with the older form of apparatus. Another feature of the bottle makes it of use to the chemist at the cement plant, where it very often happens that cement is obtained with a specific gravity higher than 3.20. In the new bottle the bulb itself contains only



Improved Specific Gravity Bottle.

19.5 cc., the graduation of the stem beginning at the latter point, and thus the range of the apparatus is extended to cements having a specific gravity as high as 3.28.

In making a determination with this bottle, the writer has usually pursued the following plan: The bottle is filled with kerosene to slightly above the mark on the lower stem of the bottle. The bottle and the sample of cement whose specific gravity is desired, are then placed side by side on a table and allowed to remain there for one-half hour. At the end of this time, a thermometer is placed in the flask with its bulb well down in the lower bulb of the latter. As soon as the temperature is constant, the reading is taken, the thermometer withdrawn, the oil sucked off by means of a piece of glass tubing (drawn out to form a small pipette) until it reaches the lower bulb of the stem. A funnel is then inserted into the upper stem of the apparatus and the cement is added gradually, being made to flow through the neck of the funnel by means of a wire. While the cement is being run into the flask, the latter should be tapped gently against the table.

If the top of the latter is of stone, a piece of blotting paper may be laid over this to prevent breakage. When all the cement has been introduced into the flask, the reading is taken, a thermometer is again placed in the oil, and the temperature again observed. By the use of the corrections and table shown below, the specific gravity may be found.

The temperature corrections are based upon the fact that the coefficient of expansion of kerosene is 1.009, that of glass is 1.000025 and the difference in expansion is 0.000875. Since the bulb of the flask (to the lower mark) has a volume of 130 cc., the correction for every degree C. difference in temperature will amount to 0.000875×130 or 0.11 cc. Hence for every degree rise in temperature of the second thermometer reading over the first, we must deduct 0.11 cc. from the observed reading on the upper stem of the bottle and for every degree drop in temperature we must add 0.11 c.c. The table below shows the correction to be added or subtracted for various changes in temperature.

CORRECTIONS FOR CHANGES IN TEMPERATURE.

For a rise in temperature deduct from the observed reading of the specific gravity bottle, for a decrease *add*.

°C.	cc.	°C.	cc.	°C.	cc.	°C.	cc.
0.2	0.02	1.2	0.13	2.2	0.24	3.2	0.35
0.4	0.04	1.4	0.15	2.4	0.26	3.4	0.37
0.6	0.07	1.6	0.18	2.6	0.29	3.6	0.40
0.8	0.09	1.8	0.20	2.8	0.31	3.8	0.42
1.0	0.11	2.0	0.22	3.0	0.33	4.0	0.44

VALUES OF SPECIFIC GRAVITY IN TERMS OF THE READINGS OF THE LE CHATELIER APPARATUS, WHEN USING 64 GRAMS OF CEMENT.

cc.	0.00	0.02	0.04	0.06	0.08
19.50	3.282	3.279	3.275	3.272	3.269
.60	3.265	3.262	3.258	3.255	3.252
.70	3.249	3.246	3.242	3.239	3.236
.80	3.232	3.229	3.225	3.222	3.219
.90	3.216	3.213	3.209	3.206	3.203
20.00	3.200	3.197	3.194	3.190	3.187
.10	3.184	3.181	3.178	3.174	3.171
.20	3.168	3.165	3.162	3.159	3.156
.30	3.153	3.150	3.147	3.143	3.140
.40	3.137	3.134	3.131	3.128	3.125
.50	3.122	3.119	3.116	3.113	3.110
.60	3.107	3.104	3.101	3.098	3.095
.70	3.092	3.089	3.086	3.083	3.080
.80	3.077	3.074	3.071	3.068	3.065
.90	3.063	3.059	3.056	3.054	3.051
21.00	3.048	3.045	3.042	3.039	3.036
.10	3.033	3.030	3.027	3.025	3.022
.20	3.019	3.016	3.013	3.011	3.008
.30	3.005	3.002	3.000	2.997	2.995
.40	2.992	2.989	2.986	2.983	2.980
.50	2.977	2.974	2.971	2.969	2.966
.60	2.963	2.960	2.957	2.955	2.952
.70	2.949	2.946	2.944	2.942	2.939
.80	2.936	2.933	2.930	2.928	2.925
.90	2.922	2.919	2.917	2.914	2.912

ANALYZED CHEMICALS.

By J. T. BAKER,

President of the J. T. Baker Chemical Co.

The purity of chemical reagents has been a subject for much discussion for some years past, in both chemical meetings and publications, and as a result chemical manufacturers have made strenuous efforts to improve their products by offering chemicals under various significant names, such as "Blue Label," "Tested Purity," Chemicals that "do not require preliminary testing," Chemicals guaranteed under the "Pure Food and Drug Act," "Analyzed Chemicals," etc. All of these efforts have helped the situation more or less but the significant thing about it all is the increased interest which the subject has aroused both pro and con, the result of which promises to work beneficially to all concerned. The different schemes are of course all more or less open to criticism but the criticism comes principally from those who do not appreciate innovations or who are not inclined to fall in with new ideas which are not of their own invention.

The term "Chemically Pure" even when emphasized by the word "strictly" has lost most of its time honored significance, and it is a curious fact that it began to fall under suspicion about the same time that the mythical nature of the atom was discovered. There was a time when the young graduate chemist emerged from college, with his degree under his arm, ready to swear by anything that was labeled "C. P.," and even the experienced chemist seldom took the trouble to go farther than to read the label on his bottle. That was in the days when the chemist was of much less importance about an industrial plant than he is today and when great accuracy was not required of him. Conditions have changed, however, and today the chemist has become one of the most important factors in every industry from steel making to farming, and analytical work has of necessity become very accurate in its requirements.

To do accurate work one must have the best facilities, and in analytical work not the least important requisite is chemical reagents that are of the highest purity and which can always be relied upon. To meet these requirements, the life of the chemical manufacturer has been made miserable at times by the demands of the chemist, for while the manufacturer is limited by the extent of his skill on the one hand and by forced economy on the other, the chemist sees no limit but absolute purity. Much confusion arises from a misunderstanding of the term "C. P.," to the manufacturer it means highest degree of purity attainable under the conditions of manufacture, while to the chemist it means absolute purity. It long ago became patent to every one that some standard of purity must be established which would be satisfactory to both the manufacturer and consumer. The Bureau of Standards, at Washington, first undertook the problem but the undertaking proved impractical and appears to have been abandoned. Then the "Pure Food and

Drug Act" was enacted by Congress compelling the manufacturer to guarantee his products to be honestly labeled, but this law was intended primarily to apply to foods and drugs and has been of very little practical value as regards chemical reagents, for guaranteeing foods and drugs is an entirely different proposition from guaranteeing C. P. chemicals.

In the first place what does the term guarantee signify? In common usage it has various significations. If one buys a piece of machinery under a guarantee he expects in case of failure to have his money refunded. If he buys a pair of shoes under a guarantee he expects nothing, for a guarantee under such circumstances is only an extra inducement to make a sale and neither the seller nor the buyer has any idea of what is being guaranteed. A government guarantee means that if goods are adulterated or mislabeled the manufacturer will, upon sufficient evidence, be prosecuted. But no one of these different forms of guarantee can be of any value to the chemist, for in the first place he can get very little satisfaction in simply knowing that his investment in a few chemicals will be refunded after an important analysis has been ruined by reason of some unsuspected impurity in his reagent, nor in the second place is he foolish enough to expect that the Pure Food and Drug Commission will take up the case because the label reads C. P. but contains say five hundredths or five thousandths of one per cent of some impurity. Hence an ordinary guarantee on a "C. P." chemical is of no more practical value than a guarantee on a pair of shoes.

If every chemical could be made absolutely pure, then "Guaranteed C. P." would mean something or the chemical name alone would suffice, but absolute purity is impracticable and even "highest purity" is a variable quantity. The only alternative is to state the degree of purity and this can be done best by a statement of analysis showing the impurities tested for and the amounts present, if any. The effect is reassuring even if of no great practical value, for the analysis furnishes a standard of purity for both manufacturer and consumer, because each knows exactly what the label means. The manufacturer cannot be accused of deceit and the consumer cannot be deceived, for if the purity of the chemical as shown by the analysis does not come up to his idea of "C. P." he does not have to accept it. If it contains impurities that are objectionable for certain kinds of analytical work and not objectionable for others, he can exercise his own judgment about using it. The only intelligent use of the term "C. P." is in connection with an analysis and the latter is in itself a practical guarantee of quality and one about which there can be no misunderstanding.

Of course the analysis is open to the criticism that it may not be accurate and to some it might look suspicious to see the same amount of impurity given repeatedly as is sometimes the case when it is minute. As regards accuracy, allowance must always be made for the "personal equation" and to eliminate this fac-

tor as far as possible, results must be gotten down to a mathematical basis. This can be done only by taking samples of material sufficiently large to remove all doubts about the result, for many substances such as iron, aluminum, sulphur, calcium, etc., can always be found in appreciable amounts if sufficient quantity of material is taken for testing. When taking samples as small as 2 or 3 grams the results are often doubtful, for precipitate from a sample say 25 grams might be very decided and yet escape notice in a very small sample. By taking a sample large enough to make a quantitative determination and stating the results in per cent all doubts are removed, and even if the figures run out to the third and fourth decimal place, the statement is far more satisfactory and reassuring than to take it for granted that a reagent labelled "C. P." will always run uniform even when of the same make. Reagents in which no trace of impurity of any kind can be detected in a sample as large as say 20 or 25 grams can be made when desired but they are often too expensive and unnecessary for the general run of analytical work, while "Analyzed" reagents answer practically the same purpose at no greater cost than the so-called "C. P." reagent. If no impurity can be detected in a 25 gram sample, the result can safely be put down as "none" while if the amount is too small to be weighed, it can be indicated as less than any one milligram (.001%). A precipitate for instance of BaSO_4 containing as small an amount of SO_3 as 0.00001 gram can be detected with the eye and yet this amount is insignificant.

Good judgment is required in taking samples and when the product does not run uniform in quality, as in the case of many salts, samples have to be taken more frequently than when it is more uniform, as with liquids. Qualitative tests must be made continuously during the process of manufacture and the quantitative test must be made when the material is finished and ready for bottling. To insure accurate work the testing must all be done by skilled chemists and contamination through possible carelessness in handling and bottling or mistakes in labeling can be avoided by employing systematic methods.

A manufacturer of "Analyzed Chemicals" stands in his own light occasionally, as for instance when some chemist who looks at things superficially buys an "Analyzed Chemical" and looking at the analysis and seeing that certain impurities are present, at once decides that the chemical is not pure and returns it. He wants a chemical that is "C. P." He is like the chemist who received a bottle of bromine packed in a tin can with chalk and opening the can and discovering the chalk he immediately returned it with a letter stating that he did not want powdered bromine, he wanted the liquid. However, these occurrences are rare and "Analyzed Chemicals," as well as all the other special makes of C. P. chemicals, notwithstanding the criticism which each may be open to, are receiving the endorsement of chemists generally, judging from the

fact that any of the different makes can be found more or less on the shelves in every chemical laboratory.

CHEMICAL ANALYSIS OF PORTLAND CEMENT.¹

Before submitting the cement to a chemical analysis it should be passed through a No. 100 test sieve to free it from pieces of clinker too large to be quickly attacked by the acid.

Weigh 0.5 gram of cement into a wide platinum or porcelain dish. The former is the more expensive of the two, but it is a better conductor of heat and there is no danger of contaminating the solution with silica, etc., from the dish, if the evaporation is conducted in platinum. The silica can also be entirely removed from a platinum dish. Now stir up the sample of cement in the dish with 10 c.c. of cold water until all lumps are broken up, and add immediately 10 c.c. of cold dilute hydrochloric acid (1:1). Place the dish on a water bath and evaporate to dryness, stirring occasionally. The water-bath will evaporate as fast as anything else and there is no danger of the silica's spattering, which it is apt to do, unless the operation is very carefully watched, when a hot plate is used. As soon as the contents of the dish are dry, cool, add 10 c.c. of dilute hydrochloric acid and 30 c.c. of water, digest 5 or 10 minutes on the hot plate, filter and wash 10 times with hot water. Evaporate the filtrate to dryness. Cool, add 10 c.c. of dilute hydrochloric acid and 50 c.c. of water to the contents of the dish, cover with a watch glass and digest on the hot plate for 5 or 10 minutes. Filter off the slight residue of silica on a 9 cm. filter, wash well (7-10 times) with hot water and put in a weighed platinum crucible together with the silica obtained from the first filtration. Ignite over the bunsen burner until all the filter paper is consumed and then ignite strongly over a blast lamp for 10 minutes. Cool in a desiccator and weigh as SiO_2 ; multiply the weight by 200 per cent of silica, SiO_2 .

Heat the filtrate to boiling and add a faint but distinct excess of ammonia. This can be most conveniently done by means of a bottle, fitted with a siphon tube, the end of which terminates in a jet, connected to it by a short piece of rubber tubing, which is closed by a pinch cock. The bottle stands on a shelf over the reagent table, and the siphon extends to within six inches of the surface of the table. The beaker is placed under the jet, and the ammonia can be very carefully and conveniently added by pressing the pinch cock. After adding the ammonia replace the beaker on the hot plate and boil for 5 minutes. Remove from the hot plate and allow the precipitate to settle. Filter on to an 11 cm. filter paper and wash once with hot water to collect the precipitate in the cone of the filter. Invert the funnel over the beaker in which the precipitation was made and wash practically all of the precipitate into this, allowing the filter to remain in the funnel. Dissolve the precipitate in 20 c.c. of 10%

¹Method used in the laboratories of the Dexter Portland Cement Co., Nazareth, Pa., Pennsylvania Cement Co., Bath, Pa., etc.

nitric acid (1:10) and dilute the solution to 100 c.c. Heat to boiling and reprecipitate with ammonia as before. Boil for 5 minutes, allow the precipitate to settle and filter through the same filter paper as used for the first precipitation. Wash once with hot water. Ignite carefully in a weighed crucible over a bunsen burner and finally blast for 5 minutes. Cool and weigh as combined oxides of iron and alumina $\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$. This precipitate also contains manganese dioxide, phosphoric and titanate acids, all of which are present in small quantities in the cement. Determine the iron oxide as directed further on and deduct from the combined weights for the alumina, Al_2O_3 (Phosphoric acid, titanate acid, etc.)

Make the filtrate from the iron and alumina alkaline with ammonia; boil and add 20 c.c. of boiling saturated ammonium oxalate solution (or better 3 grams of solid ammonium oxalate dissolved in 25-50 c.c. of boiling water just prior to use). Stir well, allow 15 minutes to settle, filter on an 11 cm. filter and wash ten times with hot water, using as little as possible (about 100-125 c.c.) to do the work well. Proceed as in A or B.

A. Gravimetric.—Place the precipitate in a weighed platinum crucible, ignite, and weigh, after ignition over a blast-lamp to constant weight, as calcium oxide, CaO . Report as such.

B. Volumetric.—Transfer the paper and precipitate to the beaker in which the latter was formed, and opening, spread it out against the upper side of the beaker. Wash the precipitate off the paper with a jet of hot water, fold the paper over, add 50 c.c. of dilute (10%) sulphuric acid (1:10) to the contents of the beaker, dilute to 150 c.c. and heat until the liquid is between 60° and 90° C. Titrate with permanganate solution until the pink color is produced. All this time the paper should be sticking to the walls of the beaker. Now drop this into the solution and stir. The pink color of the latter will be discharged. Finish the titration very carefully by adding permanganate, a drop at a time, and calculate the lime.

If the filtrate from the lime measures over 250 c.c. acidify and evaporate until this bulk is reached. This can be rapidly done by using a large (8 in.) porcelain dish in the following manner: Place a piece of wire gauze on a tripod and in the center of this a round piece of this asbestos paper about the size of a silver dollar. Now place the dish on this and a bunsen burner turned fairly low under the asbestos dish. The contents of the dish can then be made to evaporate rapidly, without boiling, by regulating the flame. When the solution measures 250 c.c. transfer to a beaker. If necessary, cool and, when perfectly cold, add 15 c.c. of a 10% solution of sodium phosphate and 25 c.c. of strong ammonia. Stir thoroughly and set aside in a cool place for at least six hours. Filter, wash with a mixture of water 800 c.c., ammonia (0.96 sp. gr.) 200 c.c. and ammonium nitrate 100 grams; place in a weighed platinum or porcelain crucible and ignite over

a low flame until all carbon is burned off. (Do not use the blast lamp). Cool in a desiccator and weigh as magnesium pyrophosphate, which weight multiplied by 0.7238 gives the percentage of magnesia, MgO .

Weigh 1 gram of finely ground cement into a small beaker and add 15 c.c. of dilute hydrochloric acid, heat from 10 to 15 minutes and add a little water. Heat to boiling and filter¹ through a small filter, washing the residue well with water and catching the filtrate and washings in a small beaker. Add to the solution 5 c.c. of dilute hydrochloric acid and bring to a boil. Add carefully, drop by drop, stannous chloride solution (25 grams in 100 c.c. of dilute 1:3 hydrochloric acid) until the last drop makes the solution colorless. Add 3 drops in excess. Remove from the burner and cool the liquid by setting in a vessel of cold water. When nearly cold, add 15 c.c. of saturated mercuric chloride solution and stir the liquid with a glass rod. Allow the mixture to stand for a few minutes, during which time a slight white precipitate should form. Run in standard bichromate solution carefully from a burette until a drop of iron solution tested with a drop of 1 per cent solution of potassium ferricyanide no longer shows a blue, but instead a yellow color. Multiply the number of cubic centimeters of bichromate used by the ferric oxide equivalent per cubic centimeter of the bichromate and divide the product by the weight of the sample. The result multiplied by 100 gives the per cent of the ferric oxide in the cement. The most convenient strength for the standard bichromate solution is 3.074 grams of the salt to the liter. One c.c. of this solution is equivalent to 0.005 gram ferric oxide. It should be standardized against iron wire or ferrous ammonium sulphate.

Weigh one gram of the sample into a small dry beaker and stir it up with 10 c.c. of cold water until all lumps are broken up and the lighter particles are in suspension. Add 7.5 c.c. of dilute (1:1) hydrochloric acid and heat until solution is complete. Filter through a small paper and wash the residue thoroughly. Dilute the filtrate to 250 c.c., heat to boiling and add 10 c.c. of boiling 10% barium chloride solution. Stir well and allow to stand over night. Filter, ignite, and weigh as BaSO_4 , which multiplied by 0.43291 gives the percentage of SO_3 .

A Chilean company named El Melon, with a capital of \$486,650, has established a plant at Calera, a few miles from Valparaiso. The capacity of the plant is 200,000 bbls. per annum, which will about supply the normal demands of Chile. The customs duty on cement is 15% on a valuation of 4 pesos, or \$1.46 United States gold, per 100 kilos, or 220 lbs.

The opening of the plant, in which the president of Chile and many prominent business men of the republic participated, was made a holiday in that locality. It marks a decided advance for the industrial development of the country.

¹May be omitted if the cement practically all dissolves. Most cements do.

METALLURGY.

PULVERIZED COAL VS. PRODUCER GAS AS A FUEL FOR NODULIZING FINE IRON ORE IN THE ROTARY KILN.

By A. P. HACHTMANN, M. E.

Of the Lehigh Car Wheel & Axle Works.

The heat treatment of fine iron ore in the rotary kiln is practiced in order to change the ore from its finely divided state to a condition which will permit it to be charged into the blast furnace for final reduction.

The process consists in feeding the finely divided ore into a rotary kiln and subjecting it to high temperature in the presence of air. During the process of heat treatment, not only does the ore undergo a physical change, but a chemical change also takes place, which consists in the expulsion of sulphur and arsenic which might be present in the ore. It is therefore not only essential that the furnace be maintained at the proper temperature, but it is also imperative that the heated ore, during the period of heat treatment, be exposed to a sufficient quantity of air to assist the expulsion of the loose atoms of sulphur or arsenic which are liberated by the mere application of heat, and by successful oxidation render decomposition complete.

Various furnaces have been devised in the several districts in which ore roasting is practiced. The office of this paper is to confine our attention to the rotary kiln as a nodulizing furnace and compare the results obtained with this type of furnace when using either producer gas or pulverized coal as fuel.

The rotary kiln is a cylindrical reverberatory furnace. It consists of a steel shell about 7 or 8 ft. in diameter and about 100 ft. long. This shell is carried on two girth rollers supported by carriers at slightly different elevations, thus giving the kiln a slight inclination to the horizontal. The inner surface of the furnace which is subjected to the high roasting heat is lined with fire-brick. About midway between the girth rollers is a girth gear which is fastened to the kiln shell. The gear meshes with a pinion in the driving bed, and by means of this set of gears the kiln may be given a rotary axial motion. Provision is made so that the speed of rotation of the kiln may be varied to suit furnace conditions. The higher or feed end of the kiln terminates in a brick housing which serves to support the stack required to discharge the waste products of combustion. The lower or discharge end terminates in a hood lined with fire-brick. The material to be treated is fed into the kiln at the stack end by means of a suitable feeder. The fuel is fed in at the discharge end of the kiln by means of a burner which enters the brick work of the hood approximately in the center of the kiln.

The finely divided iron ore drops from the feeder to the slowly revolving hearth of the furnace. Inasmuch as the hearth is slightly inclined downward toward the discharge end, the ore slowly travels the entire length of the furnace, passing gradually from a zone of comparatively low temperature to successive zones of gradually increasing temperature, until finally it reaches the zone of maximum temperature. If the elements of heat, air supply and time have been well balanced, the ore issuing from the discharge end of the kiln will be found to have assumed a nodular form about the size of a black walnut, and if the iron is analyzed it will be found to have a comparatively low content of sulphur and arsenic.

In so far as the temperature necessary to nodulize iron ore is concerned this temperature may be obtained either with producer gas or by means of pulverized coal. The intensity of heat obtainable with a fuel is, however, a secondary consideration in a nodulizing operation. The main point at issue is temperature control and control of the flame.

When finely divided iron ore is subjected to high temperature, it assumes a plastic condition in a short time, and the fine particles begin to arrange themselves in small balls or nodules. The size of these nodules is governed by proper heat regulation. If the distribution of heat in the various zones of the furnace is not favorable, the material will adhere to the fire-brick lining and gradually build up until the furnace is completely closed. When this condition asserts itself, the heat must be drawn, the feed discontinued and the kiln must be kept rotating until the heated mass of ore has sufficiently cooled to enable laborers to enter and pick and bar it out. During this time, which usually covers a period of twenty-four hours, the kiln is idle and therefore non-productive.

In order to overcome this kiln sealing action, experience dictates that the furnace be heated by a flame which radiates its heat to the ore, and not by a flame which impinges in the material being treated. This then brings us down to the question of the choice of fuel and the method of burning it in the furnace.

Pulverized coal is generally introduced into the furnace through a burner by means of a blast of air or by means of natural draft induced by the kiln stack. The rate at which coal is fed to the burner can be closely and accurately regulated in either constant or variable quantities. The core of fuel issuing from the burner nozzle can be varied to suit the conditions under which the furnace must be operated. This close regulation of fuel supply over so wide a range means that the temperature of the furnace can be varied over the same wide range. The flame resulting from the use of finely pulverized fuel is therefore always absolutely under the control of the kiln operator. If the

zone of maximum temperature is to be within a few feet of the discharge end of the kiln, the fuel supply can be regulated to meet this condition. If the zone of maximum temperature is to be farther away from the discharge end, this condition can also be met. This shows how flexible the system is, and how readily it can be accommodated to suit furnace conditions. The length of the flame, its direction, its volume, its intensity, are all subject to the will of the operator. These are the main points at issue, and the facility and ease with which they are attained show conclusively that pulverized coal is exceptionally well adapted for the purpose of heating metallurgical furnaces treating finely divided iron ore.

When a rotary nodulizing furnace is heated with producer gas, it is necessary that the gas be burned in large quantities with a resultant large flame. The rate of flow of gas to the furnace can be varied. Each variation in the gas supply will result in a corresponding change in the size of the flame. This flame, instead of assuming the core-like cylindrical shape resulting from the combustion of pulverized coal, spreads out and moves in a wavy course over the greater portion of the hearth. The furnace charge being distributed along the entire length of the hearth in a narrow stream of practically uniform thickness, is therefore subjected for a considerable stretch to the heating action of this flame, which transfers its heat to the material, not by radiation, but by impinging both on the furnace charge and on the lining of the kiln. This transference of heat over so extended a zone causes the ore in this entire zone to become plastic and adhere to the lining bricks. Any additional material entering this zone assumes the same plastic condition with the result that the material builds up on the hearth until finally the furnace is effectually sealed.

During the period that the furnace is open the quality of the material discharged by a gas-fired kiln does not compare in any way with the material discharged by a furnace fired with pulverized coal. The nodules produced by a coal-fired kiln are regular in form and uniform in density. The material produced by a gas-fired kiln does not have a nodular appearance, but rather the appearance of a flat irregular slab. Instead of having a good close grain, it is honeycombed and often brittle. This difference in structure is caused solely by the difference in heat treatment. If the operator has control of the furnace heat, he obtains a uniform product at maximum output. If the heat is beyond his control, he obtains a poor product and curtailed output.

Flame and temperature control are the most important elements entering into the successful nodulization of fine iron ores. These two factors are of such moment that they outrank and transcend in value any and all points which must be considered in order to make the operation an economical and commercial success.

Next in importance to flame control is air supply. Irrespective of whether pulverized coal or producer gas is used, the air should be preheated to a temperature which will best adapt it to the fuel it is to serve.

With the present method of introducing pulverized coal into the rotary kiln, it is possible to admit just sufficient air with the fuel to support combustion. The core of fuel enters the furnace entirely surrounded by a jacket of air. This jacket of air may be varied so that it will be just sufficient to support the combustion of the fuel, or it may be regulated so that it will be sufficient to assist in the oxidation of the iron ore in addition to supporting combustion. Inasmuch as the coal is entirely surrounded by a uniform jacket of air of even composition, it can readily be seen that combustion will be complete, and the heat evolved will be radiated through the surrounding air to the furnace and the furnace charge. If the blast pressure is varied, and the amount of fuel is varied, the length of the flame and also its intensity will be varied. If the blast pressure and the amount of fuel fed to the furnace are not varied, the flame will remain steady and its heat intensity will be constant.

Owing to furnace conditions, it is preferable when using producer gas to have the gas generated in a pressure producer. The gas from the producer enters the furnace by means of a flue through the hood. The air necessary for combustion and ore treatment may or may not enter the furnace with the gas, as the operator elects. It is, however, customary to conduct the heated air and gas to the burner through separate flues, bringing them together at the burner. Inasmuch as the gas delivered by the producer is under only a very slight pressure, care must be exercised that the air entering the furnace through the other flue be at a lower pressure than the entering gas, otherwise there will be a disturbance in balance between the incoming gas and the incoming air with disastrous results. When possible, the air should be forced into the furnace by means of a low pressure fan blower, but on account of the varying rates at which producers operate, a safer plan provides that the circulation of air be induced by the furnace draft. Furnace draft varies with furnace conditions and atmospheric conditions, so that these factors materially affect the uniformity of the air supply to the furnace. Whatever adjustments may be made, there is either an excess or a deficient supply of air. The air duct may, however, be proportioned to supply only a portion of the air required by the furnace, the balance being obtained either through the discharge opening in the bottom of the hood, or through the annular space between the kiln shell and the hood. Air supplied through the discharge opening is a variable quantity. If for any reason the opening should become choked, either on account of a rush of material or on account of a large slab becoming wedged in the opening, the air supply from this source during this period will be cut off.

Air supplied through the annular space between the

hood and the kiln is also an uncertain quantity. In the first place it enters the furnace comparatively cold. The quantity of air thus supplied is considerable. In fact more air is admitted through this opening than is required for economical operation. This results in dilution of the gas with a consequent loss in the thermal efficiency.

Summing up the advantages of air supply which one fuel has over the other, it can readily be seen that a nodulizing furnace fired with pulverized coal possesses all the advantages resulting from proper control of the air supply with none of its disadvantages. This, coupled with the fact that flame and temperature control are more complete with pulverized coal than with producer gas, shows conclusively that insofar as the mechanical manipulation of these two fuels is concerned, pulverized coal far outclasses producer gas.

Thus far we have confined our attention entirely to the mechanical manipulation of the fuel entering the furnace. It is now in order to compare the relative heat values of pulverized coal and producer gas in order to determine the economy resulting from the use of either of these fuels.

We will use a coal containing 55% of fixed carbon and 32% of volatile matter. This coal has a heating value of 13,200 B. T. U. per pound. In order to make conditions as nearly uniform as possible the same kind of coal will be used both for pulverizing purposes and for the generation of producer gas. In the calculations the following values will be used:

	Cu. ft. at 62° F.	Wt. per cu. ft.	Burning to	Oxygen required lbs.	Heat developed lbs. B. T. U.
One pound of carbon			CO ₂	2.66	14,500
Carbon			CO	1.33	4,450
Carbon monoxid 13.55	.07380		CO ₂	0.57	4,385
Carbon dioxid.. 8.60	.11627				
Hydrogen ....190.00	.00526		H ₂ O	8.00	62,000
Methane CH ₄ ... 23.75	.04210		CO ₂ & H ₂ O	4.00	23,976
Ethylene C ₂ H ₄ ... 13.55	.07380		CO ₂ & H ₂ O	3.43	21,476
Nitrogen	13.50	.07407			

THEORETICAL CLASSIFICATION OF THE COAL.

	Lbs.	Cu. ft. at 62° F.	Per cent by volume.	Wt. lbs.	Total heat value B. T. U.
Of the 55 lbs. of carbon, assume 48 lbs. burned to CO ₂	112.00	1,517.60	28.091	2,073	9,090.10
7 lbs. burned to CO ₂ ..	25.62	220.33	4.078	.474	
32 lbs. of volatile matter may have a maximum content of 65% of volatile hydrocarbons, of this amount 56% is assumed to be burned to CH ₄	10.4	247.00	4.572	.192	4,603.39
And the balance to C ₂ H ₄	10.4	140.92	2.608	.192	4,123.39
To burn the carbon 82.6 lbs. of oxygen are required. Of this amount 25%, 20.65 lbs., will be derived from H ₂ O and will liberate	2.58	490.20	9.074	.047	2,914.00
The balance, 62 lbs., will be derived from the air and occurs with	206.39	2,786.26	51.575	3.820	
		5,402.31	99.998	6,798	20,730.88

Total energy in 100 cu. ft. of gas, 20,731 B. T. U.

Total energy in 1 cu. ft. of gas, 207.31 B. T. U.

Total energy in 1 pound of gas, 3,049.5 B. T. U.

Number of cubic feet of gas per pound of coal, 54.

Number of cubic feet per pound of gas, 14.71.

Total energy in gas produced by one pound of coal, 11,104.74 B. T. U.

Total energy per pound of coal fed to producer, 12,200 B. T. U.

Percentage of heat energy in gas as compared to coal, 84.8%.

Loss of heat energy in producer, assuming ash is free of carbon, 15.2.

Without taking into consideration the heat energy dissipated by the unburned carbon in the producer ash, the heat absorbed in the producer on account of internal reactions, the loss as sensible heat in the gases, or the radiation and conduction losses, the above figures show that the producer will deliver only 84.8% of the heat value of the coal charged into it. If to this figure we add the inherent losses due to gasification, it will conclusively be proven that the producer demands at least 20 to 25% of all the heat value of the coal, and will deliver the remainder as potential in the gas.

The continuity of operation must next be considered. With pulverized coal, the full thermal value of the fuel is always present. All the combustible matter is completely burned, which means that the ash will have no carbon content. No ash handling system is required as the furnace automatically takes care of any ash falling on the revolving hearth. Part of this ash is delivered at the discharge end with the material treated, the balance finds its way out through the stack. If furnace conditions require a change in temperature, this can instantly be effected without loss of fuel or loss of product. In other words a furnace fired with pulverized fuel is always capable of being efficiently operated at its maximum capacity.

With producer gas, the furnace operation depends entirely upon the continuity of the flow of gas, and the uniformity of its composition. Both these elements are subject to change through a wide range. With each variation, a corresponding change in furnace conditions takes place, which means that the speed of rotation of the kiln must be varied, causing a change in the amount of material being fed to the furnace. The output of the kiln is therefore variable and the operation generally inefficient.

Finally, we will consider the installation and operating costs of plants suitable for pulverizing fuel and generating producer gas.

To nodulize 200 tons of iron ore in 24 hours, there will be required 16 net tons of pulverized coal. Assuming that the producer delivers to the furnace 84.8% of the heat energy in the fuel gasified, there will be required 18.86 tons of coal if producer gas is used. The cost of the pulverizing plant will therefore be based on a capacity of 16 tons per day and the cost

of the producer plant will be based on a capacity of 18.86 tons of coal per day.

To pulverize 16 tons of coal per day, the following equipment will be required:

1 crushing roll.....	\$ 585
1 rotary dryer.....	1,200
3 elevators.....	750
1 33" Fuller-Lehigh mill....	1,700
1 motor.....	600
1 bin.....	400
Foundations.....	250
Shafts, belts, etc.....	300
Erection.....	500
	\$6,285

To this amount should be added the cost of structure and \$500 for each furnace to cover fuel burner installation.

This equipment will have sufficient capacity to deliver the entire amount of pulverized coal required in eight hours.

To gasify 18.86 tons of coal per day the following equipment will be required:

PRODUCER GAS.

3 gas producers @ \$900 each....	\$2,700
3 leads to main.....	180
1 main.....	1,000
3 bins overproducers @ \$700....	2,100
2 motors for feeders (duplicate)....	300
Foundations.....	700
Shafts, belts, etc.....	150
Gas main platform.....	1,200
Labor erecting.....	1,000
	\$9,330

To this amount should be added the cost of structure, ash handling system, and \$150 for each flue to furnace.

This equipment will have to be operated 24 hours per day in order to satisfy the demands of the nodulizing furnace.

The operating costs will be as follows:

PULVERIZED FUEL.

Coal for dryer, 1/3 ton @ \$3.00.....	\$1.00
Grinding power, 50 h. p. @ 3/4 cent per h. p. hour (8 hours).....	3.00
Attendance, 1 man @ \$1.75.....	1.75
Supplies.....	.75
Repairs and interest @ 6%.....	1.50
	\$8.00

Cost per ton of pulverized coal, \$0.50.

PRODUCER GAS.

2 gas men @ \$2.25 (12 hr. shifts).....	\$ 4.50
2 laborers @ \$1.75 (12 hr. shifts).....	3.50
10 h. p. @ 3/4 cent per h. p. hour (24 hours)....	1.80
Supplies.....	.75
Coal required for generating steam on basis of 1/3 lb. steam per pound of coal burned in pro-	

ducers, assuming one pound coal evaporates

9 pounds water, 7 ton @ \$3.....	2.10
Repairs and interest @ 6%.....	3.00
	\$15.65

Cost per ton of coal gasified, \$0.83.

These figures are conservative and show conclusively that not only is the first cost of installation less for a pulverizing plant than for a producer gas plant, but it also shows that the operating cost of a pulverizing plant is almost one-half the operating cost of a producer gas plant.

Summing up all the various points mentioned, it is evident that pulverized fuel is much better adapted for nodulizing iron ore than producer gas.

THE BEHAVIOR OF CALCIUM SULPHATE AT ELEVATED TEMPERATURES WITH SOME FLUXES.¹

By H. O. HOFMAN AND W. MOSTWITSCH,

Massachusetts Institute of Technology.

The materials used in these experiments were calcium sulphate, lead oxide, ferric oxide and silica. They were carefully prepared to insure the highest degree of purity, it being recognized that even traces of foreign matter in the small amounts of material treated (0.5 gram or less) would lead to inaccuracies in the results. The calcium sulphate was prepared by dissolving the purest commercial calcium carbonate in hydrochloric acid, and after separating the iron with ammonia, the lime was twice precipitated with ammonium oxalate to free it from magnesia. The calcium oxalate was ignited to oxide, dissolved in hydrochloric acid and the calcium precipitated from an ammoniacal solution with ammonium sulphate. The calcium sulphate was then dried for use. The lead oxide was obtained by igniting at 800°-850° C. lead peroxide, which had been deposited electrolytically from a nitric acid solution of pure lead nitrate. The ferric oxide was prepared by igniting to constant weight pure ferrous ammonium sulphate. The silica used was a specimen of Brazilian quartz, which showed by analysis 99.96 per cent silica.

The heating, measuring and testing apparatus consisted of an electric-resistance furnace of the tube form, constructed by W. C. Heraeus; a Le Chatelier, thermo-electric pyrometer, and railroad tubes with testing solutions as follows: For the detection of SO₂, a colorless solution of potassium iodate and starch; for the detection of SO₃, a solution of barium chloride acidified with hydrochloric acid, and for the detection of both SO₂ and SO₃ a barium chloride solution acidified with hydrochloric acid and charged with bromine.

Behavior of Calcium Sulphate.—From 0.2 to 0.4 gram of the salt (CaSO₄ + 2H₂O) was heated in puri-

¹Abstract of a paper read before the Chattanooga meeting of the Amer. Inst. Min. Eng., and published in the January issue of the Bulletin.

fied, dry air in a platinum boat. The start was made at 500° C, and the heating prolonged every time to constant weight. The sample was held for a fixed time after each heating in a desiccator containing sulphuric acid and soda-lime, and then weighed to an accuracy of 0.1 mg. The essential of these results are recorded in Table I. The table shows that all the water is given off at about 900, and that there is no further change between 900 and 1,180.

TABLE I.—EXPULSION OF WATER FROM HYDRATED CALCIUM SULPHATE.

Sample No.	Character of Substance.	Weight of Substance Before Heating.	Temperature.		Time.	Weight of Substance After Heating.	Loss in Weight.		Loss in Weight or Water.
		Grams.	Deg. C.	Min.		Grams.	Grams.	Per Ct.	
1	Air-dry hydrated calcium sulphate containing 20.25 per cent of water.	0.3577	500	60	0	0.2866	0.0711	19.87	
			600	40	0	0.2863	0.0714	19.96	
			700	40	0	0.2859	0.0718	20.07	
			800	40	0	0.2855	0.0722	20.18	
			900	60	0	0.2853	0.0724	20.24	
			950	40	0	0.2853	0.0724	20.24	
			1,000	30	0	0.2853	0.0724	20.24	
2		0.4194	1,100	30	0	0.2853	0.0724	20.24	
			1,180	30	0	0.3344	0.0850	20.26	

The next experiments were made with anhydrous calcium sulphate, obtained by heating the moist salt to constant weight at 1,150°. From these it is shown (Table II) that anhydrous calcium sulphate in pure, dry air at atmospheric pressure remains unchanged up to 1,200° C.; that dissociation begins at 1,200°, and increases with each increment of temperature; that fusion, accompanied in part by dissociation begins at 1,360°, the sulphur trioxide liberated being split up into sulphur dioxide and oxygen; that the composition of the product is governed by the temperature, and therefore decomposition cannot be complete without fusion, as has been believed.

TABLE II.—DECOMPOSITION OF ANHYDROUS CALCIUM SULPHATE BY HEAT.

Sample No.	Character of Substance.	Weight of Substance Before Heating.	Temperature.		Time.	Weight of Substance After Heating.	Loss in Weight.		Remarks.
		Grams.	Deg. C.	Min.		Grams.	Grams.	%	
3	Anhydrous sulphate calcium.	0.252	1,200	15	0	0.2515	0.0005	0.28	
			1,200	15	0	0.2513	0.0007	0.28	
			1,200	15	0	0.1969	0.0004	0.30	
			1,200	15	0	0.1967	0.0002	0.30	
			1,300	10	0	0.1913	0.0006		
			1,300	10	0	0.1869	0.0044	7.7	
			1,300	10	0	0.1833	0.0036		
4	Anhydrous sulphate calcium.	0.1973	1,300	10	0	0.1821	0.0012	30.2	
			1,400	10	0	0.1369	0.0604	42.1	
			1,400	10	0	0.1112	0.0861		
			1,400	10	0	0.1112	0.0861		Substance fuses.

Behavior of Anhydrous Calcium Sulphate with Silica.—Silica does not undergo any physical changes up to 1,600° C., when it begins to fuse (researches of Day and Shepherd). It was supposed that the decomposition of calcium sulphate would be accompanied with the formation of a silicate, hence the mixtures were made in definite molecular proportions. The substances having been ground together, were placed in a platinum boat and heated in the furnace at 500° C. for some time, and then the temperature was gradually raised. All charges became constant in weight at 900°, slight changes occurring on account

of moisture absorbed in preparing the mixtures.

1. Bi-Silicate Charge, $\text{CaSO}_4 + \text{SiO}_2$.—Sample No. 6 yielded sulphur dioxide at 1,000° C. Sample No. 7 lost 40.72 per cent of its weight after being heated for 60 min. at 1,300, the total SO_3 present being 40.52 per cent. Continued heating for 30 min. gave no additional loss.

2. Singulo-Silicate Charge, $2 \text{CaSO}_4 + \text{SiO}_2$.—Sample No. 9, containing 23.10 per cent SiO_2 instead of the theoretical 23.18 per cent, gave off SO_2 first at 1,000°. On heating for 60 min. at 1,250° to 1,300°, it lost 46.29 per cent of SO_3 instead of the theoretical 45.23 per cent. Further heating gave no change in weight.

3. Tri-Silicate Charge, $2 \text{CaSO}_4 + 3 \text{SiO}_2$.—Sample No. 10 began to give off sulphur dioxide at 1,000°, and on heating for 60 min. at 1,250° it suffered a loss of 35.27 per cent instead of the theoretical 35.31 per cent. Further heating gave no further change, showing that the decomposition was complete.

In order to prove that the above silicates were formed the following experiments were made: From each silicate 0.1 g. was boiled with water, the solution filtered, and the filtrate tested for alkalinity and for dissolved lime. Phenolphthalein showed only slight alkalinity, and a scarcely visible turbidity was produced by ammonium oxalate. Further, the silicates were completely soluble in dilute hydrochloric acid; from these solutions ammonia precipitated silicic acid, and from the filtrates calcium oxalate was precipitated.

The decomposing effect of silica upon calcium sulphate may be said to be founded upon the stronger affinity that silicate has for lime than for sulphur trioxide above 1,000°, and on account of its stability and infusibility, permitting the displacement of the more volatile and less refractory sulphur trioxide. The results obtained justify the deduction that the decomposition is due to the formation of silicate, and that the reaction is complete at a temperature varying from 1,250° to 1,300°, which is below the melting point of the silicate. It is interesting to note that the decomposition of calcium sulphate by means of silica is practically complete at about the same temperature which begins the dissociation of calcium sulphate alone.

Behavior of Anhydrous Calcium Sulphate with Ferric Oxide.—Preliminary experiments were made with ferric oxide heated alone and with a small proportion of magnesia to 1,500°. The loss in weight of the ferric oxide alone was but 0.23 per cent, although the charge was fritted, and the mixture suffered no loss up to 1,490°. A mixture of calcium sulphate and ferric oxide corresponding to the ratio, $\text{CaSO}_4 + \text{Fe}_2\text{O}_3$, was gradually heated in pure, dry air. At 1,100° C. there was no change in weight; further heating yielded sulphur dioxide and oxygen; the evolution of gas increased with the rise of temperature, and was apparently strongest at from 1,200° to 1,250°. At 1,200° the charge was fritted; at 1,225° it began

to fuse, and at $1,250^{\circ}$ it melted to a ruby-colored liquid, which upon cooling crystallized as calcium ferrite. Further tests showed that fusion could take place without complete decomposition, a mixture of ferric oxide, lime and calcium sulphate being formed, and that the formation of the ferrite continues in the liquid mass until the decomposition is complete.

Table III gives the figures for additional experiments with calcium sulphate alone and with fluxes heated for 10 min. periods to obtain data for progressive rises of temperature.

TABLE III—DECOMPOSITION BY HEAT AND FLUXES OF ANHYDROUS CALCIUM SULPHATE

Sample No.	Substance.				Loss.			
	Composition	Weight	Sulphur Tri-oxide	Silica.	Temperature	Time.	In Weight.	In Sulphur Tri-oxide.
		Grams.	Grams.	Per Ct.	Deg. C.	Min.	Grams.	Per Ct.
5	CaSO ₄	0.1691	0.09941		1,200	10	0.00035	0.35
					1,250	10	0.0013	1.31
					1,300	10	0.00435	4.38
					1,350	10	0.0177	17.80
					1,400	10	0.0362	36.45
6	4 CaSO ₄ : SiO ₂ Sub-silicate	0.1829	0.0978	9.09	1,000	10	0.00045	0.46
					1,000	10	0.0018	1.84
					1,150	10	0.00335	3.43
					1,200	10	0.0076	7.77
					1,250	10	0.01185	12.12
7	2 CaSO ₄ : SiO ₂ Singulo-silicate.	0.2033	0.09783	18.15	1,000	10	0.0007	0.71
					1,100	10	0.0032	3.27
					1,150	10	0.0060	6.13
					1,200	10	0.0125	12.78
					1,250	10	0.02215	22.64
8	CaSO ₄ : Bi-silicate.	0.2415	0.09838	30.72	1,000	10	0.0004	0.407
					1,100	10	0.00345	3.51
					1,150	10	0.0068	6.92
					1,200	10	0.0172	17.50
					1,250	10	0.0344	34.99
9	2 CaSO ₄ : 3 SiO ₂ Tri-silicate.	0.2430	0.08579	39.95	1,000	10	0.00065	0.76
					1,100	10	0.00635	7.4
					1,200	10	0.02115	24.66
					1,250	10	0.0384	44.76
10	CaSO ₄ : Fe ₂ O ₃ Calcium Ferrite.	0.4915	0.13296		1,000	10		
					1,100	10	0.00075	0.56
					1,150	10	0.0030	2.26
					1,200	10	0.011	8.27
					1,250	10	0.0417	31.37
					1,300	10	0.1271	95.60

Behavior of Anhydrous Calcium Sulphate with Lead Oxide.—It has been found by other experimenters that lead oxide begins to be volatilized at 800° C., which is 83° below its melting point, and that the volatilization ratio reaches 12.7 per cent at $1,000^{\circ}$. A mixture having the ratio, PbO + CaSO₄ was heated in dry, purified air. No change took place until 700° was reached, when the lead oxide began to be volatilized. The heating was stopped at $1,200^{\circ}$. Tests afterward showed that there was no decomposition of the calcium sulphate.

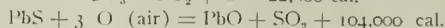
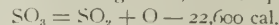
APPLICATION OF THE EXPERIMENTAL RESULTS TO SOME METALLURGICAL PROCESSES.

1. *The Carmichael-Bradford Process.*—The gypsum added to the charge of raw sulphide lead ore, is decomposed mainly by silica and ferric-oxide; the sulphur dioxide resulting from the dissociation of sulphur trioxide set free enriches the gases.

Gypsum has no decomposing effect upon galena.

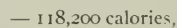
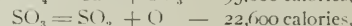
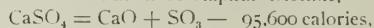
The lead sulphide of the charges is oxidized by the oxygen of the air blown into it; the sulphur trioxide dissociated into sulphur dioxide and oxygen at the

temperature of decomposition of calcium sulphate cannot have any oxidizing effect in the hot parts of the charge; in the upper cooler region of the converting-pot there is a possibility of some sulphur trioxide being formed from sulphur dioxide and oxygen with the assistance of a catalyzing effect of the charge, but even here the newly-formed sulphur trioxide can hardly have an oxidizing effect, as the equations



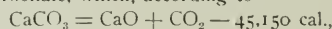
point toward the strongly exothermic direct oxidation by means of the excess of free oxygen present in the gases.

The decomposition of calcium sulphate with the simultaneous dissociation of sulphur trioxide,



represents two strongly endothermic reactions which must be favorable to the roasting of galena, as they counteract any tendency to local overheating and consequent fusion of the charge.

Further, the sulphur dioxide set free has a loosening effect upon the charge and thus acts favorably upon the process. From the thermal considerations it appears that in blast-roasting galena, calcium sulphate has a more favorable effect upon the result than calcium carbonate, which, according to



absorbs less heat.

2. *Ordinary Oxidizing-Roast.*—In the ordinary oxidizing-roasting of ores the temperature is usually not raised to above 900° or $1,000^{\circ}$ C. As gypsum is not decomposed at this temperature, its presence can but have the effect of increasing the percentage of sulphur in the roasted charge.

3. *Oxidizing-Roast of Calcareous Blende.*—In the oxidizing-roasting of calcareous blende the calcium carbonate is converted into calcium sulphate; and the latter, not being decomposed at the temperature of from $1,200^{\circ}$ to $1,250^{\circ}$ C. attained in the operation, might be expected to increase the sulphur-content beyond the degree it actually does were it not for the presence of small amounts of silica in the gangue and of isomorphous iron sulphide in the blende converted into ferric oxide, both of which favor the decomposition of calcium sulphate, and are thereby helpful in the diminution of the sulphur-content.

4. *Reduction of Roasted Calcareous Blende.*—On the other hand, the presence of large amounts of isomorphous iron sulphide in blende, as in many marmites, has a harmful effect upon the reduction of roasted calcareous blende on account of the low temperature ($1,250^{\circ}$ C.) at which calcium ferrite fuses. The reduction of zinc oxide in practice is carried on at a temperature of $1,300^{\circ}$ C.; the fused calcium ferrite, which is very fluid, will penetrate the charge, hinder reduction, and make rich residues; further, it

will have a corrosive effect upon the retort-material.

5. *Knudsen Process for Pyritic Smelting.*—In this process, it will be remembered, copper-bearing pyrite is smelted in a converter lined with dolomite. Practical experience has shown that the more basic—i. e., the richer in iron—the slag, the more quickly will the lining be slagged, while slags with a reasonably high percentage of silica do not corrode the lining as rapidly. The reason for this peculiar fact now finds its explanation in the formation of readily-fusible calcium ferrate. The experiment given on page 68 has shown that magnesium ferrite does not form at a temperature as high as $1,500^{\circ}\text{C.}$; hence, the richer in magnesia the dolomite, the more resistant will it prove to slagging.

6. *Basic Steel Processes.*—The facts stated in the preceding paragraph regarding the ease with which calcium oxide is slagged by ferric oxide, and the difficulty of forming a magnesium ferrite, are important as regards the lining of basic-steel furnaces. Here it has also been found in practice that magnesia resists the corrosive effect of an irony slag much better than does lime.

7. *Role of Ferruginous Slags in Non-Ferrous Smelting.*—The fluxing effect that basic slag rich in iron from copper or nickel-refining furnaces has upon the blast-furnace-charge of acid ores, may be explained in part by the fusibility and fluidity of calcium ferrite. This oxide slag readily dissolves the less-fusible component parts of the charge, and helps to form at the desired temperature a slag of the required fluidity. The general principle of slag-formation by solution has been proved experimentally in a different way by Doelter, who found, in observing slag-formation under the microscope, that the process was one of solution, in which the mineral having the lower melting-point, after fusing, dissolved the one having the higher.

A silicon-calcium-aluminum alloy is being introduced in this country by C. W. Leavitt & Co., of New York, the analysis being approximately silicon 47 to 57%, calcium 15 to 25, aluminum $2\frac{1}{2}$ to 6%. The chief applications of the alloy are as an energetic deoxidizer and for securing a better desulphurization. It contains the two elements most useful for the deoxidation of a metal (silicon and aluminum), and also calcium, which is an energetic reagent. Added into the ladle it calms the steel and enables the tapping of sound ingots. The products of the reaction of this alloy are double silicates of calcium and aluminum, which have a low melting point, the slag rising to the surface of the steel. This alloy is said to give better results than aluminum alone, even when added in the ingot mold itself, because it forms an easily fusible slag which disengages from the steel. The alloy may be introduced either into the furnace a short time before tapping, or into the tap-holes during the tapping, or into the ingot mold instead of aluminum, or together with aluminum.

THE IMPORTANCE OF SAMPLING.

An increase of literature on the subject of sampling should be welcomed. Sampling concerns the producer and consumer alike, and is slighted by both in many instances. It often happens that persons who abide by the proverb, "Honesty is the best policy," deceive others and themselves as well by permitting undue care in the selection and preservation of samples, upon the character of which much material is valued. In many cases nothing more than common sense is required for efficient sampling, while in some cases more application is required in obtaining the sample than in analyzing it. There are, generally, some scientific considerations not to be overlooked, and a reasonable amount of intelligence and special training should be required of samplers.

Two papers on sampling, which have recently been published should interest every metallurgist and chemical engineer. The first of these, entitled, "Methods for the Commercial Sampling and Analysis of Iron Ores," represents the work of a committee of chemists from the subsidiary companies of the United States Steel Corporation. Of this committee, Mr. J. M. Camp is chairman. The paper, which was published in the *Electrochemical and Metallurgical Industry* (vol. vii, 2, p. 65), is a liberal portrayal of the methods used by leading iron and steel works chemists, and is eminently authoritative and useful, both as regards sampling and analyzing ores. It is an example of the far-sighted policy, which has done much to promote the high degree of efficiency generally evident in the mills and departments of the Steel Corporation. In the preface of a previous issue of these methods in pamphlet form it is hinted that the committee contemplates further work.

The second paper, above referred to, is entitled, "Accuracy in Sampling Coal." It is a contribution from the Arthur D. Little Laboratory of Engineering Chemistry, by Mr. E. G. Bailey, and is published in *The Journal of Industrial and Engineering Chemistry* (vol. 1, 2, p. 161). It is a careful and exhaustive study, showing the liability to extreme error of improper sampling, and the approach to accuracy of properly conducted methods. The author uniquely applies the method of least squares to show the probable error or possible precision of sampling in different ways. A plea for the use of mathematical methods instead of those relying upon judgment should be refreshing to chemical engineers at least.

The leading producers of boracic acid and prepared borax have recently been making strong efforts to stimulate the consumption of borax along all possible lines. The forms of the product designed for household use are becoming more varied and are more widely and persistently advertised. The use of borax in tanning has been considerably increased.

FERRO-TITANIUM AND THE RAIL PROBLEM.

The problem of securing satisfactory rails is still unsolved. The energy with which it has been attacked and the vigilance exercised in the treatment of rail steel have, however, brought about important results. The essential need is increased hardness or wearing quality with unimpaired toughness. Aside from the adjustment of weight and proportion of metal in the rail, heat treatment, etc., several changes from the use of standard Bessemer steel are being tested to bring about such a result. Among these are the use of low phosphorus, open hearth steel, alloy steel and ladle-refined or otherwise specially treated steel. Recently, attention has been called to a trial of so-called ferrotitanium rails on the New York Central Lines. The specifications and returns are published in *The Iron Age* (vol. 83, 12, p. 988), the following being an abstract:

The ferrotitanium rails were made, for the most part by the Lackawanna Steel Company at their Buffalo works. The process involves the addition of crushed ferrotitanium to the molten Bessemer steel as it runs into the ladle. Titanium does not necessarily appear in the finished rails, most of it being absorbed by the slag.

It has been found that the use of ferrotitanium has added to the soundness and homogeneity of the ingot metal. To the rails is added both safety and wearing quality. This was especially true in the case of Bessemer steel containing as much as 0.10 per cent phosphorus. It was necessary with this content of phosphorus to carry a lower content of carbon than is allowed in ordinary rail specifications to prevent brittleness and consequent breakage. The company had found it expedient to specify low carbon limits on account of the extremely low temperatures to which the rails in some sections of their system are subjected. As a result of trial it is shown that the flange and tread wear of ferrotitanium rails in a crossover at Fifty-sixth street, Grand Central Station, New York, is less than one-third that of the ordinary Bessemer rail which preceded them. Both rails had the following composition: Carbon 0.45 per cent; manganese 0.06 per cent; silicon 0.13 per cent; phosphorus 0.095 per cent.

Some rails now in service were rolled from steel to which an addition of 75 pounds of a 10 per cent alloy of ferrotitanium was made for 8.8 tons of steel. A lighter addition was made in some instances. With these additions and a 9 per cent crop, satisfactory wearing quality has been secured, besides the necessary ductility to prevent breakages. Such additions of the alloy to Bessemer steel, together with the requirement that heats be held for a time after the additions, would mean an increased cost of about \$2 a ton for ferrotitanium rails.

In the New York Central specifications for 1908 there was an adherence to much of the earlier Besse-

mer practice from which satisfactory results were obtained. Notable among these is the requirement for holding the metal in the converter or ladle for a time after the recarburizer is added; also for slower pouring, substituting the 1½ inch nozzle for the 2½ inch nozzle in common use. Owing to the scarcity of low phosphorus ores Bessemer rails carrying practically 0.10 per cent phosphorus are accepted, but the carbon content is diminished to prevent liability to breakage.

It is said that of the 80,000 tons of rails laid in 1908, all before August, only four broken rails are reported for the winter. Under these specifications the seconds turned out at the Lackawanna mill were very low, especially on ferrotitanium rails. It was but 0.6 per cent one day and 0.8 per cent another day, as against 2 to 3 per cent, which is considered good practice under the usual specifications.

The New York Central is also using some open hearth rails. It is the intention of the company to try out different practice and different kinds of steel until the best possible results have been obtained. The experiments are being conducted under the direction of the well known expert, Dr. P. H. Dudley.

PREPARING CONCRETE SURFACES FOR PAINTING.

Mr. F. J. Bosse gives, in *Cement Age*, the following method for preparing concrete surfaces for painting. There are two reasons why oil paint will not stick to new concrete. These are dampness and the presence of caustic lime. Time and nature will remove these objectionable elements, as the carbonic acid of the air will convert the lime to carbonate: Time can seldom, however, be allowed for this to take place before painting. The ordinary method of preparing concrete surfaces for paint consists in washing them with acid. This, however, gives rise to the formation of such salts as calcium chloride or calcium sulphate. Mr. Bosse recommends the following method: Dissolve 10 pounds of ammonium carbonate in 45 gallons of water and apply once with a brush, or make the solution weaker and give several coats, or even apply with a spray. This treatment serves to convert the lime into calcium carbonate; water and ammonia being formed. The latter, of course, is a gas, and this and the water will evaporate as the concrete dries.

According to A. W. Gregory, when a solution of a silver salt is added to a mixture of 20 cc. of aqueous ammonium salicylate (20 grams of salicylic acid, neutralized with ammonia, a slight excess of the latter added and the solution diluted to 1 litre), and 20 cc. of ammonium persulphate solution (50 grams in 1 litre), an intense brown color is produced. By this reaction .01 mg. of silver can be detected. As lead does not give this reaction, silver may be tested for in presence of this element: 1.1 mg. of silver may be detected in this manner in the presence of .2 gram of lead.

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

HENRY WYSOR, Metallurgical Editor.

PUBLISHED MONTHLY BY

THE CHEMICAL ENGINEER PUBLISHING COMPANY

355 Dearborn Street, Chicago

Entered as Second Class Matter, Aug. 19, 1907, at the Post Office at Chicago, Illinois, March 5, 1879.

Subscription—United States, Cuba and Mexico \$2.00

Extra postage to Canada 25c a year; to foreign countries 50c a year.

Remittances may be made by check, draft, or money order in favor of THE CHEMICAL ENGINEER PUBLISHING CO.

All matter connected with subscriptions or advertising should be sent to THE CHEMICAL ENGINEER PUBLISHING CO., 355 Dearborn street, Chicago. Anything intended for the Editorial Department should be sent directly to the Editor, Richard K. Meade, Nazareth, Pa.

NOTES AND COMMENTS.

A MODERN CEMENT PLANT.

Elsewhere in this issue will be found a description of the new plant of the Allentown Portland Cement Company, at Evansville, Pa. This plant has been selected for description in this our "Special Cement, Lime and Plaster Number," owing to the fact that the editor considers it probably the most modern plant at the present time in operation or near completion. It will embody more novel features likely to be of practical importance than any other plant at the present time under construction. The use of the Fuller-Lehigh mill for grinding, of the waste heat of the kilns for drying, the Matcham natural draft system for burning, the electrical distribution of power, including an individual motor for each machine and the storage and seasoning of clinker before grinding, all represent distinct recent advances in the technology of Portland cement. Furthermore this plant announces another important advance, in that they propose to manufacture a cement containing a greater percentage of impalpable powder than any of the other plants at present in operation in the east; following the lead of the Ash Grove Portland Cement Co. and several other mills in the west, equipped with the Fuller-Lehigh pulverizers. The innovations in this mill are by no means freakish. The engineers and chemists who have designed its layout and the details of its mechanical construction, have all had many years' experience in the cement industry, and are all men who have made many more successes than failures in designing new and untried cement machinery. In presenting this description of a Portland cement plant to our readers, therefore, we feel that we are giving them a picture of what is latest and best in the cement industry.

ANNOUNCEMENT.

With the present issue THE CHEMICAL ENGINEER adds a new department to the two already established, namely, metallurgy. From the beginning it has been the aim of the promoters of this journal to cover the field of practical, applied chemistry, by presenting to its readers the most important literature of engineering chemistry. It has always published much upon metal-

lurgy and in the new department such material will hereafter be found. This section will be a feature each month and for its special editor we have secured Prof. Henry Wysor, adjunct professor of metallurgy, Lafayette College and author of "A Text Book of Metallurgy." The present age is pre-eminently an age of information. All ordinary subjects of learning are exhaustively treated, and new avenues of research are continually being opened. It would hardly be safe to say that literature on the whole is too abundant, but certain it is that greater care than ever before should be exercised on the part of readers in selecting the reading matter most useful to their needs. A momentous task is imposed upon publishers who must select such material as best represents the subjects they put forth, and which serves the largest number of interests possible with consistency. Any conscientious publisher who accepts this task must feel his measure of responsibility for the character of literature that the public receives. Metallurgy is in itself a wide subject to which no single publication can do full justice. On the other hand each publication should adhere to certain ideals, being devoted to work in a definite sphere of usefulness. It will be the ideal and aim in this section of THE CHEMICAL ENGINEER to show the scientific and active progress of the industries and professions embraced by or related to general metallurgy. Narrow interests, personal opinions and controversies and all other matters not essential to this end will be excluded.

These columns are open to any who have anything to contribute of scientific or practical interest along the lines herein pursued. Correspondence is invited, and most careful consideration of papers intended for publication is assured. Manufacturers of metallurgical appliances are invited to send descriptions of any article of merit or process which they have developed or improved. It must be conceded that progress is dependent in no small measure upon their energy and invention. The reception which this journal has received is very encouraging to its publishers. They confidently expect the co-operation of those for whose interests it exists.

THE DEVELOPMENT OF MORTAR MATERIALS.

Primitive man, with an intelligence but little greater than that of animals, made his home as did these in the caves and wherever nature had provided a shelter from the elements or protection from his enemies. With increasing knowledge he began to fashion for himself dwellings of mud and sticks, or of stones piled one upon the other, rude fashion. Some lucky accident taught him the binding properties of a mixture of lime and sand, and how to burn limestone, and, as the result of this discovery, he had at hand the means of building more permanent structures of stone, and so providing himself with an enduring habitation, not destroyed by storms or prowling wild beasts.

Where lime mortar was first used or what people

discovered its binding properties no one knows, but it is certain that its use antedates written history. It has been found between the stones of what remains of a very ancient temple on the Island of Cyprus, supposed to be the oldest ruin in the world.

The Egyptians used in place of lime a mortar in which partially burned gypsum, or plaster of Paris, was the cementing factor, and this was employed in the construction of the Pyramids, built over four thousand years ago. The Romans, the greatest of all ancient engineers, discovered that a mixture of lime and the ashes from that great destroyer, the volcano Vesuvius, might be used as a constructive force, and formed a mortar which would harden under water, and hence could be used for the construction of aqueducts, cisterns, etc. They used it in many of their public buildings and temples, in the Pantheon, in the baths of Caracalla and in the aqueduct which supplied Rome with water, one of the engineering wonders of ancient times.

From the period of the Romans, no advance was made in building materials until the construction of the Eddystone Lighthouse in 1756. There are in the English Channel, just off the coast of Cornwall, a group of very dangerous rocks, which at high tide are partly submerged. Two wooden structures built upon them to warn sailors of their peril had experienced but a short life, owing to storms which are particularly severe in the English Channel. In 1756 John Smeaton, an English engineer, was commissioned by Parliament to build a lighthouse upon these destructive crags, and so prevent many a shipwreck. He determined to construct there something which would not only resist all the fury of the elements, but should also be a monument to his engineering skill and ability. In order to build such a structure, it was necessary to use a mortar which not only possessed strength, but also hydraulic properties. In the search for such, Smeaton discovered that a lime could be produced by burning limestone containing from 10 to 15 per cent of clay, which was superior to the lime burned from pure limestone, in that it would harden under water. Such a limestone Smeaton found at Abberton, in Cornwall, near by, and the lime from this was used in the construction of the Eddystone lighthouse, which, as we all know, has proved just what Smeaton wished it to be, one of the engineering wonders of its time.

The next improvement in hydraulic mortars came 50 years later, when Joseph Parker took out a patent on a process for the manufacture of a material to which he gave the name, "Roman Cement." He found that by burning and grinding nodules washed up on the shores of the Isle of Sheppy, containing about 35 per cent of clay and the rest carbonate of lime, he obtained a very energetic hydraulic mortar. The grinding proved to be necessary as this lime would not slake on adding water to it, as did lime containing less clay, such as Smeaton burned. Parker's Roman cement

was soon shown to be better than Smeaton's hydraulic lime, and so became much used in England.

In 1810 Edgar Dobbs took out a patent for the manufacture of an artificial Roman cement obtained by mixing carbonate of lime and clay in suitable proportions, molding the mass into bricks, burning them at a moderate heat and grinding finely the soft yellowish clinker which resulted. His improvement consisted in substituting for the natural mixture which occurred in Parker's nodules, which were of rare occurrence, an artificial one made from material abundantly found in most localities.

Fourteen years later Joseph Aspdin, a bricklayer of Leeds, England, discovered that when he burned a mixture of carbonate of lime and clay in suitable proportions and at a higher temperature than that employed by either Parker or Dobbs, the combination would partially vitrify or form clinker, which when ground resulted in a cement far superior to anything then in use. To this he gave the name "Portland Cement," because when hardened it assumed a yellowish gray color, resembling in appearance stone from the famous quarries of Portland, England. Being an artificial product, it was not dependent upon nature for its composition and the harder burning gave it greater strength than the Roman cement.

In this country as far back as 1818, suitable material was discovered in Madison County, N. Y., from which Roman cement could be made and shortly after this similar material was discovered in many other sections of the country, usually in connection with some local work of magnitude, as, for example, the Erie Canal, the Chesapeake and Ohio Canal, etc. To the Roman cement manufactured along the Hudson, the name "Rosendale" was given, and it was also later called natural cement, to distinguish it from Portland cement, an artificial product. It was not until 1875 that a company was organized in this country for the manufacture of Portland cement. This company was located at Coplay, Pennsylvania, and called itself the Coplay Cement Company. Other plants were established about the same time in other parts of the country, some of them succeeded and some failed. They all went through many trials and tribulations, but from this beginning sprung one of the greatest industries of the country.

Today the United States ranks first of the Portland cement producing countries of the world, not only in point of the quantity manufactured, but also with regard to quality.

Few people realize how much concrete construction is done in the United States. If all the Portland cement made in the country last year had been used for pavements, these would have been equivalent to a sidewalk over 25 feet wide, reaching entirely around the world at the equator. If this same cement had been made into a solid cube of concrete, a side of this would be one-fifth of a mile in length—a huge block of concrete twice as high as the Singer building in New York.

CHEMICAL SOCIETIES

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—Samuel P. Saddler, Pres.; John C. Olson, Sec'y, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN CHEMICAL SOCIETY.—W. R. Whitney, Pres.; Charles L. Parsons, Sec'y, Durham, N. H.

SOCIETY OF CHEMICAL INDUSTRY, NEW YORK SECTION.—Maximilian Toch, Pres.; H. Schweitzer, Sec'y, 128 Duane St., N. Y. City. NEW ENGLAND SECTION.—F. E. Atteaux, Pres.; W. H. Walker, Sec'y, Box 1189, Boston, Mass.

WESTERN ASSOCIATION OF TECHNICAL CHEMISTS AND METALLURGISTS.—W. D. Engle, Pres.; H. C. Parmalee, Sec'y, P. O. Box 1421, Denver, Colo.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Charles B. Dudley, Pres.; Edgar Marburg, Sec'y, Univ. of Penn'a, Philadelphia, Pa.

AMERICAN ELECTROCHEMICAL SOCIETY.—E. G. Acheson, Pres.; J. W. Richards, Sec'y, Bethlehem, Pa.

AMERICAN LEATHER CHEMISTS' ASSOCIATION.—H. T. Wilson, Pres.; H. C. Reed, Sec'y, Stamford, Conn.

The regular monthly meeting of the New York section of the Society of Chemical Industry was held at the Chemist's Club, 108 W. 55th Street, New York City, on Friday evening, April 23d. The program of the evening consisted of a paper, illustrated by exhibits and lantern slides, on "The Canadian Shales," by Professor Chas. Baskerville and Chas. Hammor; the other papers were on "The Use of Preservatives in Beer," by Max Wallerstein, and on "The Determination of Cotton Seed Hulls in Cotton Seed Meal," by G. S. Fraps.

HENRY AUGUST HUNICKE.

The chemical profession sustained a heavy loss in the death of Dr. Henry August Hunicke, on the 5th of April, at St. Anthony's Hospital, in St. Louis, following an operation the day before for an abdominal trouble. Dr. Hunicke was borne in St. Louis September 21, 1861. He was educated at various preparatory schools in St. Louis and graduated with the degree of Engineer of Mines from Washington University, in 1882. He also received the degree of Master of Science from this institution, in 1886. Immediately after graduation, in 1882, he studied for a little over a year at the Königliche Sächsische Technische Hochschule, in Dresden, devoting himself especially to technical chemistry and gas analysis, the latter under Hempel. On his return to this country he entered the chemical laboratory of the Bessemer Steel Works, at Wheeling, W. Va., but a short while afterwards returned to his native city, and took charge of the analytical and assay laboratories of the St. Louis Sampling and Testing Works. In 1894, he was elected Adjunct Professor of Applied Chemistry at Washington University, a position which he held until 1898, at which latter date, he became chemist to the Anheuser-Busch Brewing Association. Dr. Hunicke left

the Anheuser-Busch Brewing Association in 1908, to establish himself as a consulting chemist and chemical engineer in St. Louis. While professor at Washington University he was offered the presidency of the University of Toronto, which he declined.

Among Dr. Hunicke's achievements may be mentioned a new process for zinc smelting, especially adapted to the utilization of low grade ores. While with the Anheuser-Busch Brewing Association he investigated with splendid practical results the economy of fuel. At the time of his death, he was engaged in the study of the synthetic production of rubber. Dr.



H. August Hunicke.

Hunicke was an active member of a number of scientific and technical societies. He was one of the founders of the American Institute of Chemical Engineers, of which he was a vice-president. He contributed also many papers to various scientific transactions.

He was a man of fine personal appearance, untiring energy, and great enthusiasm for any cause which he espoused. His ideals were of the highest, and to know him was to like him and to appreciate his splendid ability. His loss will be felt not only by his associates, but also by that part of the profession at large, which knew him only through his valuable contributions to the literature of applied chemistry.

Prof. Geo. Lunge, the distinguished German technical chemist, will attain his seventieth birthday on September 15, 1909. It is desired by his friends and pupils that the occasion should be suitably honored, and an international committee has been formed to raise a sum of money, which will be devoted to the creation of a "George Lunge fund." This will be handed over to Professor Lunge to dispose of as he may desire. It is a further intention that a gold medal, bearing his portrait in relief, be struck and presented to him on the occasion of the celebration. Professor E. Bosshard, Eidgenössisches Chemiegebäude, Zürich, Switzerland, has charge of the collecting of the funds and any contribution may be sent him.

CORRESPONDENCE.

To the Editor of THE CHEMICAL ENGINEER:

Sir: I wish to express along with Dr. Hart my very high appreciation of the debt of gratitude which the American Chemical Society owes to the persons named in his recent letter to you, published in your issue for April. The society owes to Dr. Hart, himself, a debt which can never be adequately paid. If some appropriate means might be found of expressing appreciation of the work which has been done by these persons, I would be very glad. I must dissent very emphatically, however, from the opinion that the office of president of the American Chemical Society should be considered one which is to be given on the basis of services rendered primarily to the society. It seems to me that the only proper basis for the selection of president is the question of the services rendered by the individual to the promotion of chemistry as a science, and that we should, each year, if possible, endeavor to select for our president one of those men who stand at the very front in the development of chemical work in this country. Election to the office of the president of the society should be considered one of the greatest honors which can be bestowed upon an American chemist, and this can be the case only if the selection is made on the basis of the quality of the work done by the individual and not with immediate reference to the work which has been done for the society. I am sure that the work which these men have done for the society was carried on primarily for the service which they could in this way render to the cause of chemistry in America. The great success which they have attained in this direction is, I am sure, the best reward which they can receive. Some expression of gratitude on the part of the society, both as a whole and individually is, of course, appropriate, but such an expression ought not, as it seems to me, to take the form of election to the presidency, unless the work of the individual as a chemist, looked at from the broad standpoint of the whole chemical world, deserves this honor. The experience of recent presidents of the society scarcely justifies the statement that the office is "purely an honorary one, requiring very little of the incumbent." During the recent very rapid development, the presidents of the society have found the office one which demands a large amount of careful thought and work.

W. A. NOYES.

INDUSTRIAL AND PLANT NEWS.

Asphalt. The Barrett Mfg. Co., 219 Lake St., intends to erect a plant to cost \$1,000,000 at Sacramento Ave., Chicago, Ill. A site has been purchased for the plant, where asphalt roofing and paving materials will be prepared. The concern already has two plants in Chicago.

Brass Foundry. J. Herbert Johnson, of Milwaukee, Wis., will establish a brass foundry at Eau Claire, Wis.

Ceramics. The Jesse Bradley Co., of Mooresville, In-

diana, will soon begin the construction of a large brick and tile plant at Clayton, Ind.

Dye House. The Rockwood Mills Co., of Rockwood, Tenn., will spend about \$10,000 in enlarging its present dye house, in order to enable the plant to dye goods which it heretofore shipped to dyeing plants.

Fertilizers. The Consumers' Fertilizer Co., of Maryland will soon be incorporated with a capital stock of \$500,000. The company now has offices in the Keyser Building, at Calvert and German Sts., Baltimore. It is the intention to erect a main factory, 250x250 ft., of three stories. This will be supplemented by two storage warehouses, each 60x100 ft. The whole plant will occupy several acres of ground.

Galvanized Iron. The Berger Mfg. Co. has let contracts for the erection of a galvanizing plant at Alliance, Ohio. Two buildings will be erected. One of them will be 300x125 ft., and the other 180x100 ft. Each will be 50 ft. high and of fireproof construction.

Glue. The United States Glue Co. has awarded contracts for a \$30,000 vat house in connection with its plant at Carrollville, Milwaukee County, Wisconsin. The building will be of reinforced concrete and brick.

Leather. The Barnet Leather Co., of Little Falls, N. Y., have awarded to the Turner Construction Co., a contract for the erection of a reinforced concrete factory, 100x94 ft., and four stories high.

Paper. The Gardner-Harvey Paper Co. will build a new plant at Middletown, Ohio, which will cost \$250,000.

Paper. The Southern Cotton Stalk Pulp & Paper Co., of Atlanta, Ga., has purchased an entire block at Cordele, Ga., and will erect there a mill to make a commercial paper from cotton stalks. The property is located on the main line of the Atlanta, Birmingham & Atlantic R. R. and has an abundant supply of water. The mill will have sufficient capacity to consume all the cotton stalk produced in a territory of 20 miles around Cordele, and will cost \$150,000.

Paper. The Howard Paper Co. intends to build a paper mill at Urbana, Ohio, the cost of which with the machinery, will be about \$250,000. Bids have been asked for erecting the buildings and machinery.

Portland Cement. The Standard Portland Cement Co., of Leeds, Ala., will enlarge its plant to a capacity of 1,500 barrels per day.

Portland Cement. The Collesus Cement Co., W. R. Warren (formerly president of the Virginia Portland Cement Co.), President, has leased the plant of the Niagara Cement Co., at Buffalo, N. Y. Extensive alterations have been made, and the Collesus company expects soon to put on the market a slag cement, made under the Collesus patents.

Sulphuric Acid. The Davidson Chemical Co., Fidelity Bldg., Baltimore, Md., a concern which manufactures sulphuric acid, will build a plant at Curtis Bay, near Baltimore. A site on the land next to the Baltimore Yacht Club has been selected. A \$300,000 issue of first mortgage 6 per cent bonds has been authorized by the stockholders. This company at present operates two plants; one at Hawkins Point and the other at Canton. The present plan is to abandon both these and have the entire work concentrated at the new plant. The site selected for the plant has a mile of water front and a depth of 25 to 30 ft. of water within a few feet of the shore. The contracts have already been let for the main building, which will be about 300x200 ft., of steel and concrete, with tile roofing. It will be equipped with all the modern devices for carrying and handling acids.

Talc. The Uniform Fibrous Talc. Co. will erect mills at Talcville, N. Y., where they have secured power rights. A dam will be built and a complete power plant installed.

RECENT INVENTIONS.

The following patents relating to chemistry and metallurgy have been specially reported to THE CHEMICAL ENGINEER by C. L. Parker, 908 G Street, N. W., Washington, D. C., solicitor of patents and patent causes:

913,679. *Wood-Pulp and Process for Making Same.* Carl Bache-Wug, Berlin, Germany, March 2, 1909.

The process consists in treating the wood in the form of blocks with a solution of sodium chloride to soften only but not remove the lignin contained in the outer portions thereof, to a substantial depth, to thereby separate the fibers and then grinding up the entire blocks.

913,708. *Process of Separating Metals in Solution.* Herbert H. Dow, Midland, Mich., Walter S. Gates, Worthington, Ont., March 2, 1909.

The process consists in adding to the solution a reagent capable of producing a relatively insoluble precipitate with one of the metals, such reagents being added in an amount equal to the chemical equivalent of said one metal; and then agitating the resultant mixture until any inclusions of the other metals are substantially dissolved out.

913,735. *Process of Extracting Precious Metals from Ores.* Isidor Kitsee, Philadelphia, Pa., March 2, 1909.

The process consists in subjecting the ores to the dissolving action of a cyanide in the presence of the anolyte of an electric apparatus in which a nitrogen compound has been electrolyzed the anolyte containing an oxide of nitrogen.

913,758. *Process of Making Sugar.* George W. McMullen, Chicago, Ill., March 2, 1909.

The process consists in first cutting the sugar producing plant into slices or small bodies, next desiccating the cut material into a frangible or brittle condition, then comminuting the desiccated material, then saturating the comminuted material and finally separating the saccharine liquid from the solids and recovering the sugar therefrom.

913,762. *Process of Manufacturing Baking-Powder.* Richard Paul, Berlin, Germany, March 2, 1909.

The process consists in mixing tartaric acid with froth forming albumen, beating the mixture to froth, drying the mixture beaten to froth and mixing it with bicarbonate of sodium.

913,780. *Producing Benzene or Its Homologues From Petroleum.* Eric A. Starke, Berkeley, California, March 2, 1909.

The process consists in mixing a distillate of petroleum which contains a benzene nucleus, with concentrated sulfuric acid, then heating the mixture during agitation until the evolution of sulphur dioxide has about ceased; then allowing the mass to settle until the sulphonic acids have separated from the petroleum; and then recovering the benzene from said sulphonic acids by distillation.

913,794. *Process for Making Cement.* Edward J. Winslow, Chicago, Ill., March 2, 1909.

The process consists in preparing a relatively water proof cement by dry grinding pulverulent cement with an anhydrous water proofing compound composed in part of an inorganic alkaline agent.

913,887. *Process of Preparing Carbide of Calcium.* Xavier Herme, Fruitvale, Calif., March 2, 1909.

The process consists in placing the following substances in a receptacle in the order mentioned, namely: sugar, carbide, a refined oily substance, sugar, glucose in liquid form heated to the boiling point, agitating the substances so placed, and thereupon placing an additional

amount of sugar in said receptacle and continuing said agitation.

914,100. *Electrolytic Process of Producing Compounds.* Charles E. Acker, Niagara Falls, N. Y., March 2, 1909.

The process consists in continuously electrolyzing a molten compound of a metal, alloying the separated metal with a cathode metal, removing the alloy and reacting on the alloyed metal with production of an intermediate compound, supplying a separate reagent and reacting therewith on the intermediate compound, with production of the desired compound, and returning the residual metal to the cathode.

914,113. *Gunpowder.* Conrad P. H. Claessen, Berlin, Germany, March 2, 1909.

The explosive consists of an intimate mixture of nitrocellulose, nitroglycerin, vaseline and potassium lactate.

914,187. *Process of Manufacturing Aluminum Compounds.* Erik L. Rinman, Gottenberg, Sweden, March 2, 1909.

The process consists in directly heating a mixture of alumina-containing materials with an ammonium salt, to the temperature of reaction of said ammonium salt; generating ammonia and forming the aluminum salt of the corresponding acid of the ammonium salt.

914,214. *Electrolytic Process of Producing Nitrogen Compounds.* Charles E. Acker, Niagara Falls, N. Y., March 2, 1909.

The process consists in continuously electrolyzing a molten compound of a metal capable of forming nitrogen compounds, alloying the separated metal with a cathode metal, removing the alloy and reacting on it with a nitrogenous reagent, separating the products of reaction, and returning the residual metal to the cathode.

914,251. *Process of Chloriding Organic Bodies.* Carleton Ellis, White Plains, N. Y., March 2, 1909.

The process consists in forming useful products from naphthalene by electrolyzing a chloride and causing the evolved chloride to react upon naphthalene in a fluid form.

914,279. *Process of Obtaining Nitrogen From Air.* Oliver P. Hurford, Chicago, Ill., March 2, 1909.

The process consists in first burning a carbonaceous fuel in the presence of air of sufficient quantity for complete combustion to carbon dioxide and substantially free from carbon monoxide, then subjecting the gaseous products to the condensing action of water to condense the steam and separate the carbon dioxide from the nitrogen and then leading off the nitrogen from the condensing chamber.

914,343. *Process of Making Storage-Battery Electrodes.* Thomas A. Edison, Orange, N. J., March 2, 1909.

The process consists in associating a mass of conducting metallic particles in a cellular or honeycomb arrangement, and in subjecting the same to a welding temperature to secure integrality of said particles.

914,382. *Composition for Tanning.* Ira I. Burrows, Poolville, Texas, March 9, 1909.

The composition consists of the following ingredients: Water, fluid extract of phylolacca, or common poke root, gum gambler, and alum.

914,430. *Insecticide.* John W. Lafer, Catawba Island, Ohio, March 9, 1909.

The insecticide comprises sodium arsenite, potassium arsenite, ferric arsenite, calcium di-sulphide, sodium di-sulphide calcium arsenite and water.

914,523. *Compound Fuel.* Abraham D. Shepard, San Francisco, Calif., March 9, 1909.

The briquet consists of a mixture of normally non-briquetable coal and a low grade briquetable coal containing an inherent binder which is liberated by pressure to unite the two coals.

- 911,621. *Explosive Mixture for Combustion Engines*. Paul Winand, Cologne, Germany, March 9, 1909.

The mixture consists of a suitable diluent, and two nitrated carbon compounds, which are separately non-explosive, but which are explosive when mixed.

- 914,633. *Steel*. Henry D. Booth, Philadelphia, Pa., March 9, 1909.

The steel contains from $\frac{1}{2}$ to $1\frac{1}{2}$ per cent of copper and from 1-10 to 6-10 per cent of vanadium.

- 914,649. *Process of Preparing Red Oxide of Iron and Zinc Sulphate*. George Evans, Stroud Green, England, March 9, 1909.

The process consists in treating low grade zinc ores containing iron by treating the ore with sulphuric acid of about 50° Baume to convert the sulphatizable metals into sulphates, calcining the mixture to decompose the sulphates of iron present, and drive off the sulphur, leaching out the zinc present, and separating from the mixture the residue of ferric oxide.

- 914,680. *Process of Treating Precious Metal-Bearing Material*. Stanley S. Sorensen and George C. Westby, Murray, Utah, March 9, 1909.

The method consists in separating the valuable constituents from a solution derived by the treatment of copper ores in the wet way by bringing the solution in contact with crushed substances containing sulphide of iron of the form occurring in mattes whereby the valuable portions are precipitated.

- 914,813. *Process of Producing Nitric Oxides and Nitric Acid*. Otto Dieffenbach and Wilhelm Moldenhauer, Darmstadt, Germany, March 9, 1909.

The process consists in passing over suitable catalysts a mixture of hydrocyanic acid and a gas containing oxygen at a temperature from 300° to about 600° C.

- 914,887. *Process for Purifying Water*. Carl W. Schultze, Buffalo, N. Y., March 9, 1909.

The process consists in adding to water sulphate of aluminum, baolin and starch and filtering.

- 914,916. *Wire and Metal Cleaning Bath*. Jay C. Beneker, Pueblo, Colo., March 9, 1909.

The process consists in subjecting iron or steel to a solution of acid containing a small percentage of a compound of arsenic.

- 915,029. *Process of Detinning*. Franz von Kugelgen and George O. Seward, Holcombe Rock, Va., March 9, 1909.

The process consists in treating tin scrap in a closed vessel with dry chloride to form stannic chloride controlling the temperature to keep it high enough to effect complete detinning, but low enough to prevent attacking the iron and to condense within the vessel such of the stannic chloride as is vaporized, and draining the liquid stannic chloride from the residue of iron scrap within the vessel.

- 915,101. *Process of Purifying Rosin*. Homer T. Yaryan, Toledo, Ohio, March 16, 1909.

The process consists in treating with sulphuric acid a solution of such rosin in a hydrocarbon solvent.

- 915,633. *Sodium Sulphide*. Emerson H. Stickler, White Plains, N. Y., March 16, 1909.

The composition is a new form of sodium sulphide consisting of flakes or laminae of great purity and solubility, said laminae being of homogeneous composition and containing a high percentage of Na₂S, with a smaller amount of water than required for the crystallization of said Na₂S.

- 915,774. *Composition of Matter for and Process of Making Insulating Material*. Carl A. Keller and Bertrand G. Jamieson, Chicago, Ill., March 23, 1909.

The composition consists of sand, cement and a saponifiable waterproofing compound impregnated with a fluid insulating material.

- 915,946. *Process of Making Aldehydes*. Carleton Ellis, White Plains, N. Y., and Karl P. McElroy, Washington, D. C., March 23, 1909.

The process consists in decomposing a formate by regulated heat in the presence of a stream of gas of regulated composition passing over said formate at the point where the formaldehyde is evolved and sweeping such formaldehyde away from such point.

- 916,004. *Process of Rendering Lithopone More Stable Against Light*. Wilhelm Ostwald, Leipzig, Germany, March 23, 1909.

The process consists in adding to lithopone manufactured in the known manner a metal compound soluble in water without decomposition, having no acid reaction and being capable of precipitating zinc compounds from solutions of zinc salts, and lixiviating the mixture.

- 916,155. *Electrolytic Process*. Henry L. Hollis, Chicago, Ill., March 23, 1909.

The process consists in coating iron sheets with tin, by immersing the sheets in an electrolyte in the form of solution of a tin salt of a fluorine acid, and connecting the sheets as cathodes with an electrolytic circuit.

- 916,302. *Method of Treating Metals, Such as Steel or Steel Alloys*. Charles J. Grist, London, England, March 23, 1909.

The method consists in heating the metal to a recalcenscent period in the presence of mercury and at a recalcenscent period passing an electric current through the metal.

- 916,449. *Process for Recovering Waste Lime*. John G. Jones, Carthage, N. Y., March 30, 1909.

The process consists in purifying and revivifying spent or waste lime by reducing the same to a solid form, afterward drying the carbonate of lime in a solid form, and coarsely granulating the lime and reducing it by heat to an oxide state.

- 916,495. *Process and Apparatus for Making Calcium Carbide*. John S. Seymour, Whitney Point, N. Y., March 30, 1909.

The process consists in injecting into the combustion chamber material to be treated in pulverulent form commingled with combustible material, and with a supporter of combustion, in a blast impinging upon material to be treated.

- 916,558. *Process of Treating Glucose*. Henry A. Hughes, Philadelphia, Pa., March 30, 1909.

The process consists in treating saccharine solutions for the purpose of counteracting or eliminating the effect of sulphites and sulphurous acid residues present therein by determining the quantity of sulphites and acid residues in such solutions, and then adding thereto an aldehyde of one of the primary alcohols sufficient in quantity to combine with said sulphites and acid residues and form a different and innocuous compound.

- 916,793. *Production of Silicon*. George O. Seward, East Orange, N. J., and Franz von Kugelgen, Homcombs Rock, Va., March 30, 1909.

The process consists in producing silicon by subjecting a suitable silicon compound and a reducing agent to sufficient heat to reduce said compound and volatilize the silicon, while maintaining around or above the zone of reduction a cooler zone containing a non-oxidizing atmosphere in which the volatilized silicon is condensed.

- 916,900. *Process for Electrolytically Producing Peroxide of Hydrogen*. Gustav Teichner, Nuremberg, Germany, March 30, 1909.

The process consists in forming peroxide of hydrogen from persulphuric acid and subsequently separating the peroxide of hydrogen from the sulphuric acid produced.

The Chemical Engineer

PUBLISHED BY

The Chemical Engineer Publishing Co., 355 Dearborn St., Chicago

Vol. IX.

JUNE, 1909.

No. 6.

THE CHEMISTRY OF SYNTHETIC CAMPHOR.

By WILLIAM A. DARRAH, B. S.

The list of those compounds for the supply of which commerce has been forced to rely upon nature is being rapidly shortened; perhaps the latest substance to be synthetically produced is camphor, which, while it is an article to be found in every household, has only recently been produced by manufacturing methods on a scale to successfully compete with the natural supply.

The term "synthetic" as applied to a chemical compound is commonly and most erroneously confused

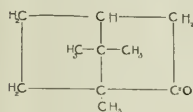


Fig. 1.

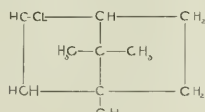


Fig. 2.

with "artificial"; though the difference is very great, particularly in the case of camphor. As correctly used the term "synthetic compound" is one produced by man though having exactly the same properties and constitution as the natural article. On the other hand, in the arts, the term "artificial" denotes an imitation of a natural product, which, while possessing some of the peculiarities of the substance from nature is yet essentially different.

This is well illustrated by the case of camphor as it happens that the two terms are used in the camphor trade for different substances. As previously stated synthetic camphor is identical with common or Japan camphor, while artificial camphor, while resembling the natural in smell and general physical appearance, is chemically quite distinct. Thus Fig. 1 shows the formula of camphor, while the constitution of artificial camphor is given in Fig. 2.

With the view of analyzing the development of the recent synthetic process, and to show the imperative need for such it may be of interest to touch in a general way upon the occurrence and extraction of natural camphor. This is practically all derived from the juice of a tree closely related to our common laurel, but which grows to very much larger sizes. This tree, the *Larus Camphora*, thrives best in the warm moist climates of southern China and Japan, from which

part of the world the great portion of the natural supply is obtained. While the name common or "Japan camphor" discloses the largest producer, yet Java, Borneo, Sumatra and the neighboring islands are the source of a large part of the world's supply.

The natural process of extracting camphor is simplicity itself, and is as inefficient as it is simple. The substance occurs as small drops or "tears" disposed between the fibers of the wood, the root being particularly rich in camphor. The trees of Borneo and Sumatra contain comparatively large tears, which are extracted by the natives after splitting the felled tree with crude wooden wedges. As thus obtained, the substance is fairly pure.

The trees of China and Japan on the other hand contain a larger number of much smaller deposits, more widely distributed, thus necessitating a more complicated process of extraction. The tree is first cut up into a number of small blocks or wedges about two inches upon a side, the faces being so chosen that

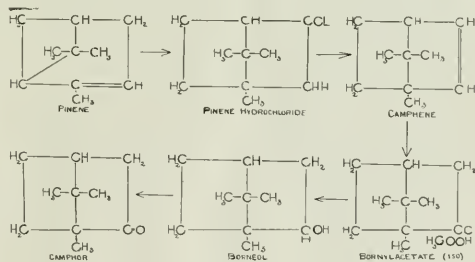


Fig. 3.

the greatest amount of fiber end is exposed. To facilitate this the blocks are sometimes shredded.

Now camphor is very volatile at ordinary temperatures, it being one of those substances which at ordinary pressures will vaporize before melting. Therefore while the melting point of camphor is twice that at which water boils, yet when the fibers of the camphor tree are heated in large vats of boiling water and the vapors are condensed, it is found that practically all of the camphor is removed, though in a very impure state. The preceding steps are usually carried out in Japan or China, where the trees abound and labor is cheap, while the final purification is done in

Europe, Germany and England being the largest refiners.

Previous to transportation the camphor distillate is filtered through straw and brush matworks, which separate the flocculent camphor. The filtrate is pressed to exclude the excess of water, thus leaving the crude camphor in the form of large impure cakes, in which shape it is exported. The further steps are the final purification, which consists essentially in fractional distillations, advantage being again taken of the ease with which the substance volatilizes.

The most casual analysis of the above process reveals one of the inherent and insurmountable defects, namely, the whole tree is destroyed in the process of extraction. Now each tree yields on an average only 20 pounds of camphor, while it requires approximately thirty years in which to mature. It must be evident, therefore, that for this reason the natural supply of camphor is kept within very narrow limits, thus giving one very important stimulus to synthetic production.

The properties of camphor are so well known that it is scarcely necessary to name them here. It is a soft semi-transparent flaky substance with a characteristic smell. Common camphor is dextro-rotary, though both laevo and racemic types are known. Advantage is taken of the rotary effect of camphor upon polarized light in determining the amount of the pure substance in the crude cake as it comes from the Orient. A weighed amount, usually about five grams, is dissolved in a 98% solution of ethyl alcohol. The solution is decanted and poured into an analyzer similar to the saccharometer used in the sugar industries. On comparing the rotary power of the specimen with a known standard from the same cake, the percentage of camphor may readily be determined.

As an ingredient in many patent medicines, as a preservative, and as the starting point in the synthesis of numerous compounds, camphor has an enormous yearly consumption. Here is, therefore, the second powerful force acting toward the development of a synthetic process. Perhaps the determining cause, however, certainly an important factor in the situation, is the fact that the natural supply of camphor is monopolized by Japan, who naturally exacts a monopoly price for the product. These three causes combined to make the synthetic production of camphor profitable: First, the large and increasing demand; second, the limited supply; third, the present monopoly of the natural article. As a result synthetic camphor has recently been introduced and is now being manufactured on a commercial scale.

The synthesis consists of six steps, but before entering upon the details it is of interest to trace the logical development of the process.

In making a survey of the possible sources from which camphor might be commercially synthesized several requirements must be kept in mind. The raw material must be cheap. It must be plentiful. It must be as closely related to camphor as possible, thereby

reducing the amount of work required in the transformation to the minimum.

The compound which most nearly fits these requirements is pinene, which as the chief constituent of turpentine oil is both plentiful and cheap, while structurally it is closely allied to camphor. In fact the closeness of this relation has led to previous attempts to devise a synthetic process. One notable instance of an unsuccessful trial was made at Ampere, N. J., and only failed after a determined effort to make a laboratory method commercial.

The first step in the procedure at present being used is the preparation of the pinene, by the fractional distillation of turpentine; that part which boils between 155 and 160° being 90% pinene, which is the principal constituent of turpentine. The formula of this substance is shown in Figure 3. It will be noted that it is double ring, aromatic, unsaturated hydrocarbon, closely related to camphor.

The distillate thus obtained is cooled and saturated with anhydrous hydrochloric acid, which transforms it from a clear, transparent liquid to a white crystalline mass. This substance is pinene hydrochloride, known technically as artificial camphor, for reasons previously mentioned. It is interesting to note the shifting of the ring formation from that characteristic of pinene to that of camphene. The addition of the hydrochloric acid is therefore an expedient by means of which the ring formation is altered and the double bond of unsaturation removed, for when, as in the next step, the acid is removed, not the original pinene but an isomer, camphene, is obtained. As shown graphically in Figure 3 the structural formula is now more similar to camphor. It will be noted that the double bond, the point at which a compound is most open to attack, is now so placed that the addition of oxygen at the required point is a comparatively simple matter.

The removal of the hydrochloric acid may be accomplished by adding any substance having a stronger affinity for the acid than the pinene hydrochloride, and not possessing any radical to give in return. Three practical methods have been devised, namely:

(a) Heating with ammonia (NH_3), amines (NH_2), pyridene ($\text{C}_5\text{H}_5\text{N}$), or similar nitrogen compounds.

(b) Heating NaOH , sodium hydrate, or a lead, sodium or copper salt of a higher fat acid, as, for instance, soap.

(c) Heating with an anhydrous acetate of sodium or lead in glacial acetic acid (CH_3COOH). The latter method gives the purest product.

Having removed the hydrochloric acid (see Figure 3), the next step is to add on the necessary oxygen at the carbon atom next the double bond. Now it is almost impossible to oxidize an organic compound directly without destroying the substance; however, some other radical may be first added and an oxygen atom then substituted. This is the process followed in this case.

The camphene previously formed is dissolved in its own volume of glacial acetic acid and 5% of fuming

hydrochloric acid added. The product thus formed is isobornyl acetate, an oil boiling at 225° , but, like camphor, volatile with steam. The structure is shown graphically in Figure 3.

It now only remains to replace the acid radical by oxygen and the process is complete. This is done in two steps. Since sodium hydrate has a stronger affinity for the acid than the isobornyl acetate, it might be expected that in the presence of this base the acetic acid would be separated; and such is the case. On adding a concentrated solution of sodium hydrate borneol is formed and also a by-product of sodium acetate. A glance at the structure shows that when the OH or hydroxyl grouping of the borneol is replaced by oxygen, thus forming a ketone compound, the process is complete.

Such a secondary alcohol is readily oxydized, chlorine, oxygen, ozone, nitric acid and a wide range of other oxydizing substances being available. Chlorine is commonly employed in practice and the yield, while not theoretical, is very satisfactory from a commercial standpoint. The product thus obtained is purified by sublimation after which it is put upon the market. With two exceptions the synthesized product is identical with the natural. The exceptions are: First, the synthetic camphor is purer than the common variety, and, second, the laboratory camphor is of the racemic type (i. e., it is not optically active), due to the fact that equal quantities of dextro and laevo rotary camphor are produced.

The melting point of iron which has been commonly accepted is nearly 100° C, too high for the melting point of pure iron, as shown by figures given by H. Carpenter in *Metallogie*, November 22. He gives as the melting point of pure iron 1505° as measured by the Le Chetelier pyrometer and 1491 to 1510° for the optical scale. The freezing point is independent of the gas in contact with the metal, a fact difficult to explain when we know that oxide of iron is quite readily dissolved by the molten iron.

Reinforced-concrete ties have been in use for several years on the Italian state railways, and the railway administration is said to have placed a contract recently for 300,000 of these ties. The cost is about \$1.25 per tie, and the life is said to be three or four times that of the wooden ties. One tie in every thousand will be broken, and investigation made as to the character of the concrete and its bonding with the steel. The manufacturers are also required to guarantee the ties for one year, replacing all those which fail in that time.

The accumulation of incrustation is, of course, very objectionable in every form of boiler, as, irrespective of the wear and tear it entails, it is the cause of loss of efficiency. It has been definitely stated that scale $\frac{1}{8}$ in. thick causes a waste of at least 15% of the fuel, besides the labor of cleaning.

CHEMICAL SPECIFICATIONS FOR SULPHITE PULP.*

J. A. DE CEW.

Owing to the variety of woods that are now used in the manufacture of sulphite cellulose, as well as the different chemical and physical treatments existing in the process, there is a considerable variation in the character and quality of the sulphite fibers that may be found in the open market. The suitability of a certain sulphite for a particular class of paper is generally determined by mill trials in which a large amount of material is involved in the experiment, and this method often results in some very expensive information.

It is therefore desirable for the promotion of accuracy in the selection of a suitable sulphite fiber for paper manufacture, that the characteristics which differentiate the various sulphite stocks, should be definitely recognized and agreed upon by the paper and pulp chemists.

In order to further develop the scientific treatment of this subject, some distinctive chemical conditions are herewith referred to, which may serve as a basis for the preparation of suitable specifications for exact requirements.

In the isolation of the sulphite fiber, by the resolution of the lignified portion of the wood, some of the less resistant celluloses have entered solution, while a portion of the more resistant ligno-celluloses remain associated with the fiber. To remove the latter and purify the cellulose, bleaching agents are used, and when but a small amount of these are required, the fiber is classified as an easy bleaching pulp. The relationship between the amounts of bleaching powder required for the production of a No. 1 white, is already an established basis of comparison for the grading of cellulose materials which require to be bleached.

For most classes of paper but especially those which are made from unbleached fiber, the structure of the individual fibers and their ultimate strength are characteristics of great importance. Under the microscope some fibers can be seen to be on the point of breaking, others in fragments and other quite sound. Many broken fibers will indicate a brittle condition in the entire fiber, which might have been caused by severe thermal treatment or the formation of hydro-cellulose by free sulphuric acid in the cooking liquors. Perhaps this latter point has not been proved, but it is a reasonable supposition. May there not be a relationship between the amount of hydro-cellulose in the fiber and the ultimate strength, and would the percentage of cellulose dust in the fiber be a means of grading or classifying the stock?

Without doubt, when strength in fiber is a requisite, a standardized sieve test would give some very valuable results, for a strong flexible fiber carries very little dust.

*Read at the meeting of the American Institute of Chemical Engineers, Pittsburg, Pa., Dec. 28th, 1908.

An ideal fiber is one that is not only strong, but is also easy to bleach and size. These characteristics are seldom combined except in the most carefully prepared stocks, for one pulp may bleach easily and yet be very difficult to size, on account of the presence of inorganic impurities which are quite injurious to the sizing agents. Sulphites have been known to contain an ash as high as 1.5 per cent, and of this about 1 per cent was sulphate of calcium. Owing to the presence of this calcium salt precipitated from the cooking liquors, the water became very hard in the heating engine, and as soon as the size was added, calcium resins were formed, with the result that very little sizing effect was obtained.

The percentage of ash therefore has a direct bearing upon the ease or difficulty, with which a sulphite may be sized, and when it is necessary to make a hard sized paper, the amount of ash in the fiber should be as low as possible, and preferably under 0.5 per cent.

A difficulty that is often caused by certain sulphite stocks, is the accumulation of a dark pitchy matter upon the felts and rolls of the paper machine. This pitchy material comes from fiber which is made from woods of a more resinous character than usual, such as balsam, tamarac or pine. The resin in the pores of the wood, being insoluble in the acid liquors used, remains in the fiber and may be recognized microscopically either imbedded in the pits or unattached. When the resin content of the fiber is 0.5 per cent or over, the unattached resin particles begin to stick to the press rolls and accumulate in the form of pitchy lumps. The percentage of resin in the fiber, is therefore a fairly good indication of the kind or quality of wood used in the process of manufacture, the amount being greater when balsam jack pine or inferior grades of spruce are used.

Some of the chemical determinations that may be applied to sulphite fibers, may be epitomized as follows:

1. The amount of ligno-cellulose material present, in terms of the amount of bleach required to destroy it.
2. The percentage of ash and the amount of sulphates it contains.
3. The percentage of resinous matter determined by extraction.
4. The percentage of dust, consisting of cellulose fragments, separated by sorting with a sieve.

From these tests it is quite possible to determine the general characteristics of a fiber, and its suitability for the purpose for which it is required.

The deposits of copper, from copper sulphate electrolytes, are rendered smoother and brighter by the presence in the electrolyte of either tannin, resorcinol or gelatine; tannin is the most effective, resorcinol is less, and gelatine is the least effective of the three. Pyrogallol is not a suitable "addition-agent" for this electrolyte, as it causes the deposited copper to form dark colored.

ACTION OF SULPHURIC ACID ON GRANITE.

By CHARLES V. BACON,

Consulting and Analytical Chemist, 610 Madison Ave., New York City.

It very often becomes necessary to know the action of acid on stone. In this particular case, it was to determine if granite could be used to make a flooring where there would be considerable free sulphuric acid. In order to determine this I have tried a series of experiments to find out how sulphuric acid of 50° Baumé or about 62% H_2SO_4 acts on granite. The samples were procured from a reputable dealer, the different kinds being:

Barre Stone,
Hergon Island,
Quincy,
Connecticut,
Clarks Island.

The experiments were conducted as follows: The samples were all examined to see that they were sound and solid, then washed to remove all dust and adhering particles; they were dried and weighed, and then placed in a glass beaker of 400 C. C. capacity and just covered with 50° Baumé sulphuric acid, this vessel in turn being loosely covered with a watch glass, and then permitted to stand for ten days. At the expiration of this time, the granite was taken out, washed, dried and weighed, the loss being figured as percentage. The results were as follows:

BARRE STONE.

Original sample.....9.1265 grammes
After 10 days.....8.9510 grammes
Loss1755 grammes 1.92%

Crumbles on the outside. Became porous and scale-like.

HERGON ISLAND.

Original sample.....10.4243 grammes
After 10 days.....10.3920 grammes
Loss0323 grammes 0.31%
No noticeable change. Very hard to crumble.

QUINCY.

Original sample.....13.1380 grammes
After 10 days.....13.0340 grammes
Loss1040 grammes 0.79%
Slight indication of becoming porous. Otherwise no noticeable change.

CONNECTICUT.

Original sample.....11.0910 grammes
After 10 days.....10.6664 grammes
Loss4246 grammes 3.83%

Structure eaten into. Crumbles under pressure of the hand.

CLARKS ISLAND.

Original sample.....11.8270 grammes
After 10 days.....11.7710 grammes
Loss0560 grammes 0.47%

Very slightly eaten into. Scale like silica rubs off. In conclusion of the above experiments, I decided that granite would not be satisfactory, as in most all cases there was some loss, or deterioration in structure.

I then tried vitrified acid proof brick; this gave all indications of being far superior to granite, the acid having practically no effect except that the brick absorbed a little acid. These bricks were used, the cement being a mixture of 20° Baumé silicate of soda and powdered silice.

This flooring after being permitted to set for a short time gave very good satisfaction.

CONCRETE BUILDINGS FOR EXPLOSIVE FACTORIES.

In a recent paper read before the Society of Chemical Industry and published in its journal, Mr. Oscar Guttman, the well-known English chemical engineer and explosive expert, had this to say of the use of reinforced concrete in the construction of the explosive factory:

"In a paper read at the Institute of Civil Engineers, on November 27, 1900, I referred to the experiments at Cummersdorf, and reported that a number of German manufacturers of high explosives, under the direction of Mr. C. E. Bichel, had built two magazines in concrete, with an aggregate of fine gravel, and that on exploding therein one and a half tons of gelatine dynamite, nothing was projected beyond a distance of fifty meters. Such magazines have since been made obligatory in Germany. Such concrete made conductive in some way, say by admixture of iron filings, might with advantage be used for buildings of explosive works generally. This idea, in conjunction with the above views upon the effect of explosions, forces upon us the conclusion that the construction of explosive buildings in wood or other light material is wrong in principle, and that concrete similar to that used at Cummersdorf, but with the insertion of a network of iron or expanded metal, should be used; in other words, ferro-concrete made with an aggregate of fine river gravel. In order to make it cheap and efficient, the roof is constructed, after the manner of wooden protecting screens for guncotton presses, with a flat inner ceiling of ferro-concrete, a layer of sand, and a thin arch of ferro-concrete (in this country arched brick magazines have already been used). A falling piece of wreckage would penetrate the ferro-concrete arch but would be stopped by the sand. The floor is also made of ferro-concrete, and the whole of the armoring being connected to earth, the building practically forms a Faraday's cage, and is absolutely lightning proof, as has been demonstrated by practical experiments on the Karts mountains by General Hess in 1884. Such a building cannot be set on fire, nor would burning wreckage be thrown about in case of explosion, whilst it would retain all small debris, and nothing, not even the iron armoring, will be projected from the building itself to a large distance. Should there be an explosion in another building, the special mound mentioned later on will prevent anything being shot in, as it were, and only such pieces have to be considered as may be thrown into the air and fall

down on the building, say such weighing one-half cwt. and falling from a height of 100 feet. Needless to say, such a building cannot easily open out or throw off its roof, but will form a solid block resisting the shock transmitted through the soil. Mr. Bichel informs me that in an explosion at the Carbonite works at Schlebusch in 1907, he has also found that his concrete magazines acted as a block which showed no cracks or other damage, although situated only 80 meters from the center of the explosion. Such a building further possesses the advantages of being warm and dry. Shafting can be readily supported, while the walls and floor can be kept quite clean by painting them over or even rendering them with a layer of cement. The cost is not very great, in fact in many cases a saving will be effected because, on account of the low roof, the mounds will also be lower. This ferro-concrete should further be permitted in the construction of mounds and entrance passages. Tunnels should be avoided wherever possible, as they frequently collapse or catch fire when made of wood."

IRON FOR ENAMELLING.

Only the best wrought-iron sheets should be used for enamelling. The composition of this should be about as follows: Carbon, 0.05-0.08; phosphorus, less than 0.03; manganese, from 0.25 to 0.35, and silicon, 0.02. A suitable cast iron for enamelling contains 3.5 per cent carbon; 2.0 per cent silicon; 1.4 to 1.8 per cent phosphorus; and 0.5 to 0.7 per cent manganese. For thin walled cast-iron articles from 1 to 2 per cent of good steel waste is added to the metal. In preparing the article for the enamel, it is usual to heat it to about 750 to 850° C. for a short period excluding it from the air while this is being done. After being allowed to cool slowly, the articles are pickled for 30 to 45 minutes in either dilute hydrochloric acid at 20 to 30° C., or sometimes in sulphuric acid at 70 to 80° C. Both these acids should be free from arsenic. In pickling cast iron articles, good results are obtained with sulphuric acid from 8 to 10 degrees B., to which 4 per cent of either stannous chloride or zinc chloride is added. During heating and pickling wrought iron ware loses about 4 per cent in weight and cast iron 3 per cent. After the pickling the articles are washed in water, scrubbed, boiled in soda-lye, and finally dried at about 130° C.

An enormous hydro-electric undertaking is being considered in France. The plan is to dam the Rhone below the rapids, some 13 miles from the Swiss frontier, and utilize the water in a fall of 230 ft. The entire upper valley of the Rhone would thus be formed into a long, narrow lake. The plant would generate 240,000 kw., half of which would be transmitted to Paris, about 280 miles distant, at a tension of 120,000 volts. It is estimated that this work would cost about \$16,000,000, and could be completed in seven years' time.

EXPERIMENTS ON THE ELECTROLYSIS OF REINFORCED CONCRETE.*

By A. S. LANGSDORF.

The possible corrosion of the steel reinforcement of concrete structures is a matter that must appeal strongly to engineers in view of the constantly increasing use of this kind of construction. The subject in general has received considerable attention, but mainly along the lines of the effect of atmospheric action. Some experiments have been made to determine the electrolytic behavior of reinforced concrete, but thus far not on an extensive scale. Probably the most notable published work in this direction is that of Mr. A. A. Knudson, of New York, whose results are to be found in the "Proceedings of the American Institute of Electrical Engineers" of February, 1907;

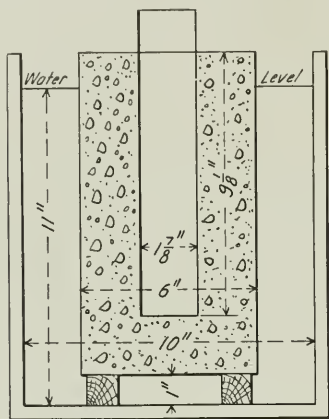


Fig. 1—Sketch Showing Arrangement of Specimen for Electrolysis Tests.

this appears to be the first account of an experimental investigation of the subject.

The experiments here described were carried out, under the direction of the writer, during the winter and spring of 1908, by Mr. M. M. Glauber, at that time a senior student of electrical engineering in Washington University. The work was undertaken as a graduation thesis and was very carefully done; its general plan was an amplification of that adopted by Mr. Knudson.

The tests made by Mr. Knudson were two in number. In the first test, three specimens (Nos. 1, 2 and 3, respectively) were made by embedding 2-in. pipe to a depth of 8 ins. in a mixture of equal parts of cement and sand; the kind of cement is not stated, but from the context it appears to have been a Portland cement. The mold was an ordinary metal pail, so that there was a thickness of between 3 and 4 ins. of concrete all around the pipe. The bottom of the pipe was closed by a water-tight plug. The specimens were then placed in water, No. 2 in fresh water and Nos.

1 and 3 in sea water. Specimens 2 and 3 were then connected in series and a steady current of 0.1 ampere was passed through them from a storage battery, the current entering through the pipe and leaving through the concrete. Specimen No. 1 had no current through it, in order to compare its condition with that of the others at the end of the test. The test was continued for a little over 30 days, current being on continuously. The results showed an unexpected deterioration of the concrete, large cracks appearing in it. There were also strong evidences of electrolytic action on the pipes, a layer of rust having formed upon them which extended into the concrete, especially on the walls of the cracks; pitting of the pipes was very noticeable, and there was an appreciable loss of weight.

In the second set of tests two blocks (Nos. 4 and 5) were made, similar to the other three except that Rosendale cement was used. The test run was again continued for 30 days with the current constant at 0.1 ampere. The results were similar to those of the first test, except that No. 4 (in sea water) showed greater electrolytic action, a hole 1 in. by 3/8 in. having been eaten clear through the pipe. In the first test, Specimen No. 1, in sea water, but without current, was absolutely unaffected. A sledge hammer and chisel were required to break it open, and the pipe was clean and bright. In all the other specimens the concrete became soft and crumbly, so that in places a penknife could be easily thrust into it.

The tests made at Washington University were also divided into two parts, but 12 specimens were used in each part. All of the specimens consisted of 1 1/2-in. pipe embedded to a depth of 9 1/2 ins. in a 1-3-5 concrete, made rather wet and thoroughly tamped. The cement was Red Ring brand (made by the St. Louis Portland Cement Co.) and the aggregate was crushed limestone. The thickness of concrete all around the pipe was 2 ins. The specimens, after aging for about 50 days, were placed in 6-gal. glazed earthenware jars, raised above the bottom by wooden blocks, and were immersed in fresh water to within about 1 in. of the top of the concrete; fresh water was added as necessary to replace loss through evaporation. Fig. 1 shows the details of the specimens.

In the first run, eleven of the specimens were then connected in series and a current of 0.05 ampere was passed through them, the twelfth specimen being without current. The run was continued for 70 days continuously. (It will be noted that in this test the current was only half that used by Mr. Knudson, and the run was more than twice as long). All of the pipes were weighed before embedding them in the concrete. At the end of each week one specimen was removed, broken open, and the pipe cleaned and reweighed, with the results shown in Fig. 2.

In the second run, which continued for 33 days, the specimens were connected as before, but the current strength was raised to 0.2 ampere. The curve showing loss of weight in this case is shown in Fig. 3;

*A paper read before the Engineers' Club of St. Louis and printed in the Journal of the Association of Engineering Societies.

during both runs, readings of the drop of voltage around the specimens were taken at regular intervals. The apparent resistance per specimen, calculated by dividing the volts per sample by the current, varied in the first run from 660 ohms at the start to

and some show also a flaky white deposit that formed on the outside surface. Lack of time prevented making an analysis of this deposit, but this will be done in a further series of tests.

The softening of the concrete observed by Mr.

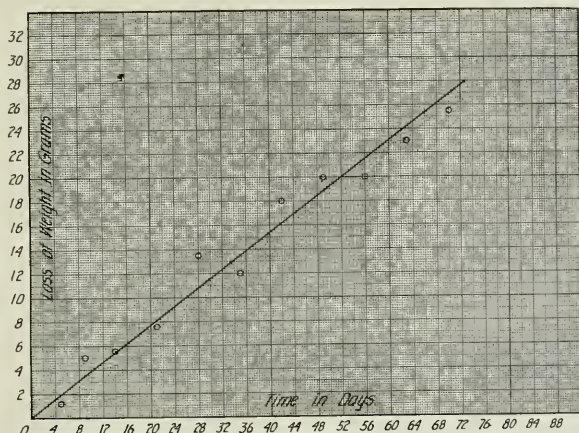


Fig. 2—Showing Loss in Weight of Concrete by Electrolysis at End of Week.

about 1,200 ohms at the end; in the second test it changed from about 50 ohms at the start to about 500 ohms at the end. Mr. Knudson found an apparent maximum resistance of from 300 to 400 ohms per specimen, but differences in this respect are to be expected because of variations in the density, or porosity,

Knudson was confirmed in these tests, but it was not so marked as reported by him, probably on account of the different mixture used. But the electrolytic action on the embedded metal was very strong, as shown by the curve of loss of weight. Whereas the specimens not subjected to the current remained clean

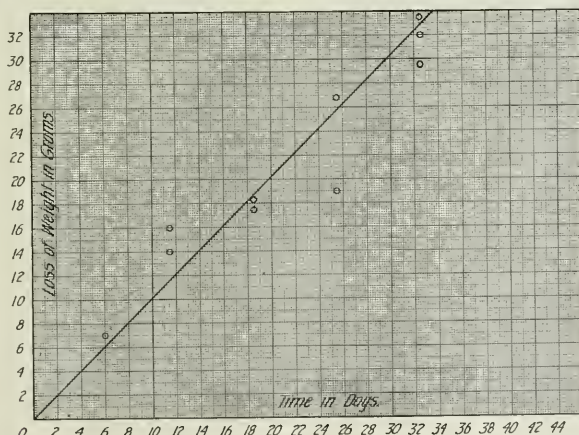


Fig. 3—Showing Loss in Weight of Concrete by Electrolysis at End of 33 Days.

of the samples. It is to be understood that these resistances are apparent only, for they include the effect of a very considerable polarization.

The specimens after their removal from the circuit show large radial cracks that formed in the concrete;

and bright, the others developed a coating of rust whose thickness increased with the duration of current flow, and in all cases where cracks developed a coating of rust was deposited on the walls of the cracks.

The cracking of the concrete may possibly be explained by the fact that the layer of rust is of rather loose consistency, so that its density is less and its volume greater than that of the original material, thus giving rise to a bursting force. The fact that the cracks are mainly radial seems to support this hypothesis.

Mr. Knudson's result, as well as those here described, indicate quite clearly that great caution must be used in the construction of reinforced concrete structures where the conditions are similar to those of the tests; such, for example, as might be found in the case of bridge abutments or concrete sewers in the neighborhood of grounded railway circuits. Further information is needed as to the extent to which the reinforcement of such structures, when buried in damp or wet earth, may become part of the return circuit of trolley lines; and also to determine the insulating effect of waterproofing ingredients in the concrete. It is the intention of the writer to take up these subjects in a further investigation, and it is to be hoped that others will also undertake the study of this important subject.

SILUNDUM.

F. Bölling has invented a form of silicide of carbon, which he calls silundum, and which he obtains by heating carbon in an atmosphere of silicon vapor. In practice this is carried out by heating carbon with carborundum, to which sand may be added, or heating carbon with a mixture of sand and carbon at a temperature of 1700° — 1800° C. The electrical conductivity of silundum is much less than that of carbon. It varies with the hardness, according to the carbon used and the length of time it is heated in the silicon vapor. The material is stable in air up to high temperatures. The chief use of the new material appears to be a permanent resistance material for high temperature work. It cannot be used, however, for making filaments for incandescent electric lamps on account of the deposition of brown silicon on the glass, owing to the fact that at high temperatures silicon vapor is given off by the silundum.

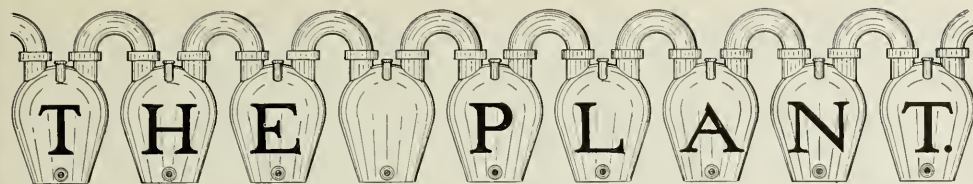
Mr. P. B. Sadtler, S. B., chemical engineer, formerly of Philadelphia, has been added to the staff of the Swenson Evaporator Co., with offices at 945 Monadnock, Chicago, Ill. Mr. Sadtler's experience of several years in evaporating lines, as well as his knowledge of the paper pulp business, manufacture of electrolytic caustic and heavy chemicals and caustic recovery from "black" liquor, mercerizing solutions, etc., will make this company especially strong in these departments. Mr. Sadtler was with the West Virginia Pulp & Paper Company, General Chemical Co. and the Geo. M. Newhall Engineering Co. and will use his experience in the selling and engineering departments of the Swenson Evaporator Co.

THE USE OF ALUMINA IN METALLOGRAPHY.

To polish metals for examination under the microscope, Mr. Robin employs alumina, which he prepares as follows: Pure aluminum (commercial aluminum is very suitable) is rolled rather thin and has a somewhat great natural polish. The metal is then cut into bands 5 mm. wide, and a bundle of them placed in a bottle containing a few c.c. of mercury, which is well stoppered. After shaking well for 2 min., the aluminum bands are taken out and placed in a crystallizer exposed to the air, or in a large glass of water covered over to keep out the dust. The same mercury can be used again for other operations. Aluminum thus treated when left in the air becomes covered with white tufts of alumina, which visibly enlarge. This operation, which seems more productive in damp weather, ceases in four hours or so. Work can be repeated until all the aluminum bands are exhausted. The alumina produced, very tenuous and light, seems to give a somewhat greater weight than that corresponding to formation of $Al_2O_3 \cdot 3H_2O$ (the alumina absorbs moisture from the air so that the process is not successful in dry air or oxygen). It can be immediately employed for polishing—that is to say, in hydrated form. Experiments with this polishing material were made at the Laboratoire d'Essais du Conservatoire des Arts et Métiers. This process may be useful to metallurgists and micrographers. Another method to treat the aluminum bands is also described in "Revue de la Métallurgie" of October.

Nitric acid is an important oxidizing agent, and all its applications depend upon this property. It combines with cotton and glycerine, forming in the first place nitrocellulose, or gun cotton, and in the latter nitroglycerine, which forms the base of dynamite. With phenol, or carboic acid as it is commonly called, it forms picric acid, and these three compounds form the basis of most of our modern high explosives. It is also used in the manufacture of many organic chemicals, particularly the Azo and Amine dyes, nitrobenzene, nitrotoluene, etc. Other products which depend upon nitric acid as a base are celluloid and the dentist's "laughing gas," or nitrous oxide, N_2O .

Iron occurs in high-grade aluminum to the extent of about 0.2% to 0.3%, and while impairing the ductability in the same way as silicon, the tensile strength is somewhat improved by its presence in small quantities. Iron does not appear to affect the electric conductivity of aluminum to the same extent as silicon, but has a bad influence on its non-corroding properties. Sodium is the most injurious impurity, as the resistance to corrosion is seriously lowered by even small quantities of this metal. Improved methods of manufacture have, however, eliminated all but the minutest traces of this element till today more than 0.006% sodium is rarely found.



THE MECHANICAL PREPARATION OF SOLIDS FOR CHEMICAL TREATMENT-GRINDING.*

Written for THE CHEMICAL ENGINEER.

One of the most important operations connected with the preparation of raw materials for chemical processes is the reduction of these to such a size that they may be conveniently handled, or else properly acted upon by heat or chemical reagents. The mechanical appliances employed for this purpose may be divided into three classes: (1) Crushers, (2) Granulators or Disintegrators, and (3) Pulverizers. The first class is intended to reduce material from the size in which it is usually obtained from the mines and the quarry to such dimensions that it will pass through the perforations of a two to five-inch ring screen. The second class is designed to take the product from the first and reduce it from this size to that of wheat. The third class is employed where it is desired to reduce material to the form of a fine powder. To a certain extent the three classes overlap. That is, the crusher will produce some powder and the granulator still more. A few pulverizers and granulators are designed to start with material in the form of lumps. It is generally considered the more economical, however, to perform the operations of pulverizing in several stages.

It is not possible to produce, even by crushing, material which will contain no powder, or be of a uniform size. In some industries, this is very important. In the case of furnaces and kilns the fine stuff would stop up the draft. In some industries, careful grinding to a definite size is very essential. Sometimes it is desirable to produce a product containing a great deal of impalpable powder. At other times, granular material containing but little very fine material is desired, and again only lump material may be wished. With cement, for example, in which impalpable powder is the active constituent and hence desired, fine grinding to a flour is necessary, and mills which produce the largest quantity of this are the ones used for its manufacture. On the other hand, with material which is to be reacted upon by a reagent in solution, impalpable powder is sometimes objectionable, owing to the fact that it makes the tailings difficult to separate from the solution by mechanical means, such as a filter, owing to the clogging of the latter by the fine material. At the same time, with the latter class it is also very necessary to have the materials sufficiently fine to allow the solutions to act upon it. When pyrites are

to be burned upon a grate for sulphuric acid manufacture, fine material is objectionable, and what is desired is an ore about the size of a walnut, as the fine material, of course, stops up the draft of the furnace.

Pulverizing machinery, as will be seen from the above, must be very carefully selected according to the results desired, as some pulverizers produce a great deal of impalpable flour, while others will grind to the same apparent degree of fineness upon a test sieve, and yet contain very little impalpable powder. Where very large grinding operations are to be conducted,

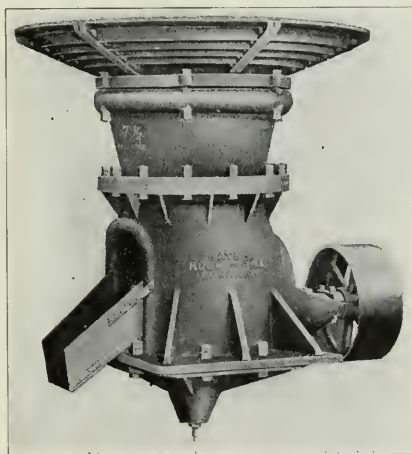


Fig. 1.

such as in the manufacture of Portland cement, or the cyanide treatment of gold ores, very careful selection of grinding machinery has to be made in order to economize power, labor and repairs, since in these processes the largest items of expense are connected with the grinding. Crushing and grinding machinery have at the present time been so far perfected as to reduce a ton of limestone as obtained from the quarry, to the fineness of 95 per cent. passing the No. 100 test sieve, at a cost of from 15 to 20 cents a ton.

CRUSHERS.

These may be divided into three general classes:

- (1) Gyratory.
- (2) Jaw.
- (3) Roll.

All of these forms are made in many sizes. As a usual thing the gyratory and roll crushers are made to take very much larger pieces of material than are the jaw crushers. Large gyratory crushers have been

*This is the fourth series of articles upon the Elements of Chemical Engineering. Former articles treated of the Materials of Construction, Storage of Materials, Conveying Materials, and Weighing and Measuring Solids, Liquids and Gases. The next series will be upon Drying.

used to reduce the hard iron ores of Minnesota, and also to handle the largest pieces of limestone which can be picked up by a steam shovel in the quarries of cement mills. At the plant of the Edison Portland Cement Co., a roll crusher system consisting of three sets of rolls has been installed, by means of which the very largest rocks which can be picked up by a steam shovel are reduced to such a size as to pass a one-inch screen.

The ease and power with which a material can be

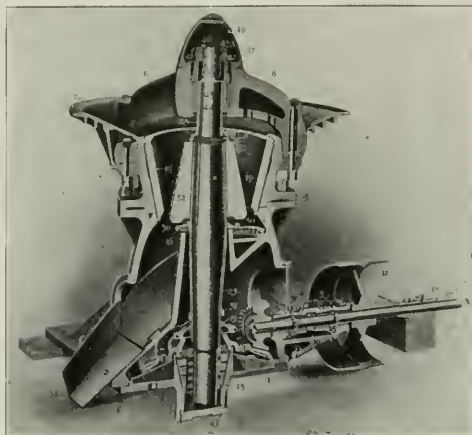


Fig. 2.

reduced is not always dependent on the tenacity of material. Cleavage has a great deal to do with this. Very often soft clayey materials are much more difficult to crush than very hard ores. This is due to the fact that the softer materials pack in the jaws of the crusher and clog up their action. Very careful selection of a crusher has therefore to be made where material of this character is handled, and usually special forms are desirable.

The gyratory crusher is shown in Figs. 1 and 2. As we have said, they are now made in very large sizes for crushing Minnesota iron ores and for limestone and cement rock in cement manufacture. For both of these purposes these crushers have been found more satisfactory than any other form. Fig. 2 shows a section of a gyratory crusher. Referring to this illustration, on the spindle 25, is mounted the chilled-iron crushing head 52. The hopper-shaped top shell 19 is lined with concave chilled plates. The crushing is done in the annular space between the chilled surfaces. The spindle, being centrally held in the spider at the top, rests at its end and passes loosely through an eccentric driven by bevels 9. The spindle thus receives a gyrating motion and may or may not rotate. Thus, one point in the annular space is wide, while a point opposite is narrow, and the crushing force is obtained on account of the head approaching and receding from the concaves.

In the type described the largest motion is at the

bottom where the annular space is narrow and this motion is the throw or stroke. The number of revolutions of the spindle and the number of strokes correspond, generally being about 200 per minute. On a crusher having an annular opening at the top, 10 in. x 60 in. circumference, the stroke would generally be about $\frac{5}{8}$ inch. These machines work continuously and for this reason are steady in the power required.

As far as oscillating motion goes they are not balanced and therefore give rise to vibration if not on good foundation. They are used for the very largest capacity. They are well adapted for careless feeding or feeding directly from cars, and the rock can be fed from all directions.

The machines are massive and repairs generally require handling large parts. On account of the side-wise rolling of the head upon the "concaves" this crusher is less liable to choke than the ordinary jaw crusher. The gyratory crusher may be obtained in a large number of sizes, varying from a capacity of 20 tons of material per hour crushed to pass a $2\frac{1}{2}$ -inch ring to one of 200 tons per hour passing a 4-inch ring. As the large crushers do not crush so fine as the small, where large capacity and a well crushed product are desired, it is usual to employ a large crusher and two or more small ones.

Gyratory crushers usually require from 1 to 1.2 hp. per ton of rock crushed per hour. That is, a crusher with a capacity of 50 tons per hour would need from 50 to 60 hp. The price of a gyratory crusher capable

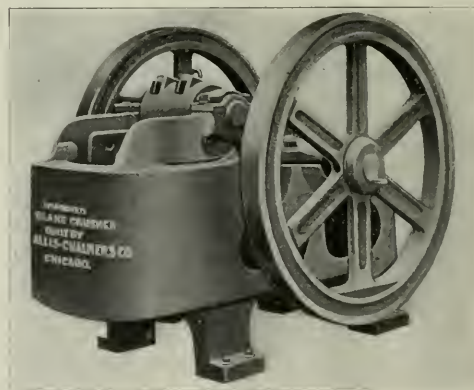


Fig. 3.

of handling about 200 tons per 10 hour day, is something like \$2,000.

Figs. 3 and 4 show the Blake crusher, a common form of jaw crusher. It consists of the following parts (See Fig. 4): *f*, the frame; *k*, zinc backing; *c*, still plate or stationary plate; *e*, movable jaw plate; *d*, pitman; *b*, swing jaw or movable jaw; *a*, toggle bearing or seats; *p*, toggles; *t*, front or toggle block; *w*, back or wedge block; side liners or checks, one at each side of mouth; *g*, shaft and eccentric; *h*, bar or swing jaw shaft.

The eccentric shaft pulls up the pitman, straightens out the toggles and this moves the swing jaw while crushing. The angle between the plates requires to be small enough to nip the rock, but large enough to give capacity or a large mouth without excessively long plates. The movement at the bottom or throat is the stroke. The number of effective strokes is the same as the number of revolutions of the pulley, since no crushing is done on the return stroke; the rod *m*

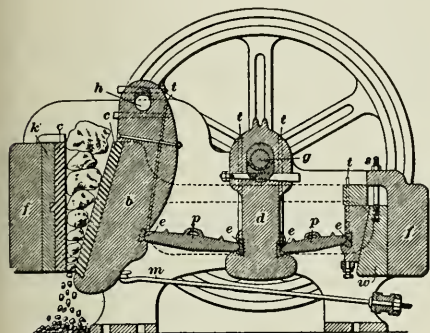


Fig. 4.

pulls the spring jaw back against the toggles during the return stroke. Half the time is occupied, therefore, in storing up energy in the flywheels.

Jaw crushers are not suited to very large crushing operations and their use is usually confined to cases where the initial expense must be kept low, as they are a cheaper form of crusher, or where a small machine with a large receiving opening is desired and great output is not essential. Jaw crushers require careful feeding of the material into them. They choke easily and much punching is required to keep the jaws fed with material.

Jaw crushers require about the same power to

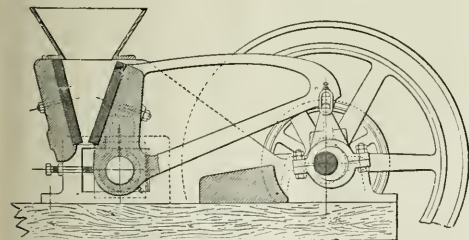


Fig. 5.

operate as do gyratory ones, the figures being from 1.3 to 1.5 hp. per cubic yard of rock crushed per hour.

Another form of jaw crusher is shown in Fig. 5 and is known as the "Dodge" crusher. In this crusher the movable jaw, *a*, is pivoted at the bottom, *b*, and prolonged at the back to form a simple lever and fulcrum. The lever, *c*, is operated as in the Blake crusher by an eccentric, *d*, and pitman, *e*. A comparison with the Blake crusher will better illustrate the prin-

ciples of the Dodge crusher and its application. As the movement of the lower part of jaw is greater in the Blake breaker when the jaw opens, a product of various sizes must drop from the machine. Whereas, in the Dodge crusher the movement is greater at the top of jaw, the lower part remaining nearly stationary and the product leaving the machine must be of nearly uniform size, determined by the distance the jaws are set apart. The Dodge crusher will therefore crush much finer than the Blake crusher, but on the other hand the Blake crusher has much the greater output.

Dodge crushers have been used to advantage in concentrating works to reduce to a uniform degree of fineness the product of the gyratory crusher.

Both of the above jaw crushers choke up easily with soft or wet material. For crushing gypsum and phosphate rock a special form of jaw crusher is used in which the movement of the jaw is such as to avoid the clogging up of the machine. Fig. 6 shows the

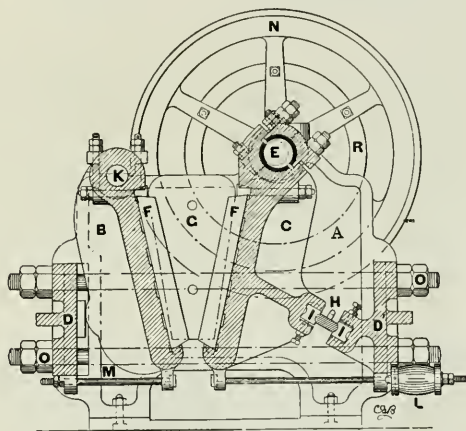


Fig. 6.

Buchanan gypsum crusher, one of the best known of these crushers.

By referring to this cut it will be seen that the moving jaw, *c*, is attached direct to the eccentric shaft, *e*, which imparts a forward crushing motion combined with a rotary downward movement to the jaw, *c*, which forces the material operated upon to the point of delivery, between the bottom of the chilled iron jaw plates, *f*, *f*, and prevents packing or choking. The bottom of the swing jaw, *c*, rocks upon the toggle, *h*, which, by the downward motion imparted by the eccentric shaft, produces a positive forward crushing movement at the bottom of the jaws. The rubber spring and spring rod, *l*, are for keeping the jaw in contact with the toggle during all portions of the stroke. The stationary jaw, *b*, is made to swing on the pin, *k*, and by means of the steel tension rods, *o*, *o*, is capable of being so adjusted so as to increase or decrease the distance between the jaws, *b* and *c*, at the bottom, thereby regulating the size of the product. The main

frame, *a*, is mounted on a separate bed-plate, *i*, which is provided with bolt holes for fastening to timbers or foundation. The end pieces of frame are cast separate and held in position by four heavy steel tension rods, *o, o*. These rods impart additional strength to the frame and take up most of the strain due to crushing; they serve, also, as a means of adjustment to crush fine or coarse. The jaw plates, *f, f*, check plates, *g*, and steel toggle bearings, *j, j*, can, when worn, be reversed.

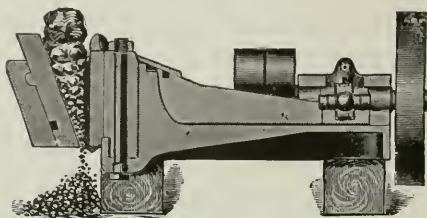


Fig. 7.

Still another form of jaw crusher is the Forster crusher shown in Fig. 7. This machine differs from those previously described, chiefly in the manner of applying the crushing force to the material. In this machine the movable jaw has a vertical bearing in the frame of the machine, and therefore with each vibration traverses a horizontal arc. This in connection with the peculiar shape of the crushing surfaces results in shearing or breaking off of portions of the material instead of delivering a direct blow, as in other jaw machines. One advantage of this crusher is that by changing the dies the same size machine may be

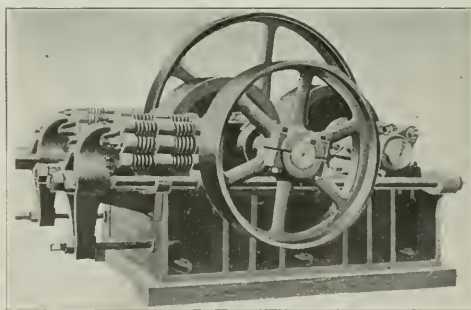


Fig. 8.

used for coarse or fine crushing. It will crush from 34-inch ring down to No. 4 mesh. A large proportion of the material passing through a 4-mesh screen will also pass 20, 40 or 60-mesh screens.

Rolls are now used extensively for both the breaking of coal and also for granulating of material. They are very economical of power and have been much more used of late years than formerly. They may be employed not only for cracking hard substances but also for granulating, and in connection with some

form of separating device, such as a screen or an air separator, have been used for pulverizing. A number of pulverizing mills now upon the market make use of practically the same method of operation as rolls.

Crushing rolls may be employed for both hard and soft substances. The latter, however, are liable to pack in the corrugations. Special rolls, made up of fine discs of metal, separated from each other by discs of smaller diameter, have been used for this class of materials.

Figs. 8 and 9 show a set of crushing rolls, the rolls themselves being only indicated by the dotted circles.

Referring to Fig. 9, which represents the machine without its dust covers and automatic feed: *A* represents the main frame, having the journals for the stationary rolls cast in one piece. *B* is the movable journal which is held in the center of the frame, *A*, by means of a heavy steel shaft, *I*, which passes entirely through the frame. The swinging journals are held in place by the tension rods, *C*, to which are attached nests of powerful coiled springs, *D*, held in position by

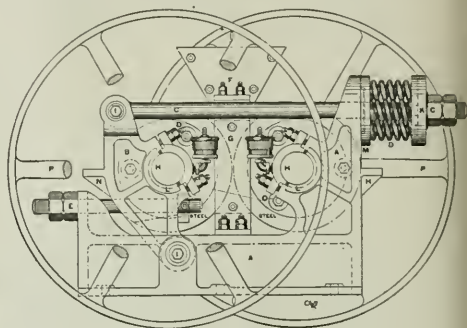


Fig. 9.

the washers *M* and *K*. The springs are stiff enough to resist the pressure imposed upon them by ordinary crushing without compression, and yield only under abnormal strains, due to the accidental passage through the rolls of foreign substances, too hard to crush, such as broken drill points, etc.

The power is applied to the rolls by means of the pulleys *P* and *P*. Both rolls are direct driven. In some forms of rolls gears are used, and one roll is driven from the other by means of these. These gears, however, are liable to wear out rapidly from the grit, etc., which always finds its way into them. Sometimes only one roll is driven. The rolls usually revolve at a surface speed of from 600 to 1,000 feet per minute. Toothed rolls are usually employed in coal breakers when it is desired to break the lump coal to smaller sizes without producing much fine material.

Rolls are often supplied with automatic feeds to regulate the stream of material passing through them. They are also usually encased in a dust proof casing.

(To be continued.)

METALLURGY

THE ELECTRIC FURNACE REDUCTION OF IRON ORE.¹

By JOSEPH W. RICHARDS.

Lchigh University, South Bethlehem, Pa.

In order that one can understand thoroughly the problems arising in the reduction of iron ore by carbon in an electrically heated furnace, he should first of all have a clear idea of how this reduction proceeds in an ordinary, non-electrical blast furnace.

BLAST FURNACE PRACTICE.

The iron ore contains iron oxide, with silica and clay as usual impurities, and more or less moisture; its phosphorus content may be low or high, but its sulphur content must be low, not over 0.5%. If the ore carries over 1% of sulphur it is given a preliminary roasting.

In the furnace, perhaps 99% of the iron oxide is reduced to metallic iron, 10 to 20% of the silica is reduced by carbon to silicon, which combines with the iron, all of the phosphorus is reduced into the pig iron, and a varying proportion of the sulphur, this proportion being smaller the more basic the slag is made with lime and the higher the running temperature.

Flux is added to make fusible slag by combining with the unreduced silica and the clay in the ore. Limestone, unburnt, is the usual flux, but magnesian limestone, carrying $MgCO_3$, is quite commonly used, the magnesia increasing the fusibility of the slag if not in greater proportion to the lime than the proportions $2CaO.MgO$. The amount of flux added is variable, it depends on how basic the slag must be made.

If the fuel is coke, and therefore considerable sulphur comes into the furnace, the slag formed must be nearly half lime and magnesia, to make low sulphur pig-iron; if the fuel is charcoal, carrying almost no sulphur, and if the ores carry none, the slag may be only one-third lime and magnesia and two-thirds silica and alumina, and still make best quality pig iron. Such slag costs less for flux and is more fusible than the basic lime slags.

Fuel is needed to provide heat and reducing effect. The heating effect is almost entirely produced by the combustion of the larger part of the fixed carbon (non-volatile carbon) of the fuel to carbon monoxide (CO) before the tuyeres. The combustion fills two functions: it provides the high temperature necessary to melt down the iron and slag, and it provides large quantities of reducing gas, practically identical in composition with producer gas (30 to 35% CO , 1 to 2%

H_2 , rest N_2), which does in the upper part of the furnace the larger part of the reduction performed in the furnace.

The amount of fuel used in a blast furnace is determined by the amount which must be burned at the tuyeres to produce the necessary smelting temperature, and not by the amount necessary to perform the reduction of the metallic oxides. The amount necessary for performing the reductions taking place in the furnace is only one-third to one-half of the amount necessary to be burned to provide the smelting heat.

That this statement is true of the ordinary blast furnace may be seen from the fact that if the smelting zone is increased in temperature by heating the blast, the amount of carbon used in the furnace per unit of pig iron made is at once decreased. Or, if the heat available in the smelting zone is increased by drying the blast, and thus removing the strong cooling influences which the decomposition of the moisture of the blast exerts, economy of fuel at once results. In fact, any means of getting high smelting temperature without combustion of carbon before the tuyeres, decreases at once the quantity of fuel necessary to use in the furnace, since the quantity used is determined by the heat requirements for reduction, which are only a fraction of the former.

The ash of the fuel is largely silica, with some alumina and lime, if coke, or alkalies, if it is charcoal. This requires, to slag it, an amount of flux which may be considerable when using poor coke high in ash. Regard for this item of cost should be had in purchasing or valuing the fuel.

The pig iron produced contains carbon between 2.5 and 4.5%, silicon in varying quantity, 1 to 4%, according to the temperature and rate of running of the furnace, practically all the phosphorus of the charge, and one-tenth to one-fourth of the sulphur. Its melting point is about $1,200^\circ C.$, and it runs from the furnace ordinarily at $1,500^\circ$ to $1,600^\circ C.$, carrying out as sensible heat 250 to 300 calories.

The slag may be basic or acid, as before explained, and these varieties will average in per cents, as follows:

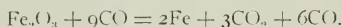
	Basic slag, high sulphur charge.	Acid slag, low sulphur charge.
SiO_2	35	55
Al_2O_3	10	10
CaO	40	25
MgO	10	5

These slags melt at about $1,350^\circ$ and $1,200^\circ C.$, respectively, and ordinarily run away from the furnace at $1,600^\circ C.$, carrying out as sensible heat 500 calories.

¹A paper presented at the meeting of the American Electrochemical Society, at Niagara Falls, Can., May 6-8, 1909.

The reduction of silica and phosphorus oxide in the furnace is accomplished by solid carbon in the smelting zone. A small part (10 to 20%) of the iron oxide in the furnace is also similarly reduced by fixed carbon; the rest is reduced in the upper half of the furnace by the excess of carbon monoxide gas. So much of the latter gas, however, is produced before the tuyeres in generating the temperature necessary in the smelting zone that only a fraction of it is converted into carbon dioxide, CO_2 , in reducing the iron oxides of the charge. This is the chief reason for the excess of unused carbon monoxide in the gases of the blast furnace, whose potential calorific value often represents one-half of the calorific power of the fuel put into the furnace.

It is true that all the carbon monoxide in the gases could not be utilized no matter how small its amount, but there is a limit set by the principle of chemical equilibrium or mass action, which ordinarily is not approached because of the excessive amount of carbon monoxide produced in the lower part of the furnace in the effort to get the requisite smelting heat and temperature. The proportions of carbon ordinarily consumed at the tuyeres are 9 atoms (108 parts) of carbon for each molecule of iron oxide (160 parts) reduced by the carbon monoxide gas. The chemical equation is:

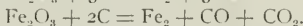
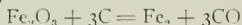


This equation shows us that only one-third of the carbon monoxide produced before the tuyeres, in generating the smelting temperature, is utilized in reduction, while two-thirds escapes unused.

ELECTRIC SMELTING FURNACE.

Passing to the electric principle of smelting, we have here to deal with the case of all necessary heat supplied by electrical energy, no blast blown in and therefore all the solid carbon utilized for reduction (always excepting the small amount which dissolves in the pig iron).

In calculating the amount of carbon necessary to thus reduce the iron oxide, we meet at the outset with this problem: What proportion of the carbon will form CO_2 and what proportion CO ? We know that when reduction takes place at a very high temperature, CO is almost the only product; but as this passes more or less slowly through the cooler portions of unreduced charge, CO_2 is formed in increasing amounts, until at a low red heat, given sufficient time, about half the CO may be converted into CO_2 . The formulas corresponding to these two extremes are:



Comparing these with the ordinary blast furnace reaction, which requires 9C put into the furnace for the reduction of Fe_2O_3 , we see that 3C, or one-third as much carbon, is the greatest amount necessary in the electric furnace reduction, and 2C, or between one-third and one-fifth as much, is the smallest amount necessary. As will be further shown, the uncertainty as to how much CO_2 can be formed in the electric

furnace reduction is perhaps the chief difficulty in running the electric furnace.

EXAMPLE.—Iron ore is to be reduced to pig iron in an electric furnace, and the flux and charcoal on hand for the charge analyze as follows:

Iron Ore.	Limestone.	Charcoal.
Fe_2O_3 90	CaCO_3 90	Fixed C. 90
SiO_2 8	MgCO_3 8	Volatile M't'r. 6
Al_2O_3 2	SiO_2 2	SiO_2 2
		Al_2O_3 1
		$\text{K}_2\text{O}, \text{Na}_2\text{O}$... 1

Assume the pig iron made will contain 4% of carbon and 3% of silicon; that the slag may be 65% SiO_2 plus Al_2O_3 ; that the gases contain only the CO_2 from the limestone, and none from the reductions.

Required: (1) The parts by weight of ore, limestone and charcoal to charge 100 parts of pig iron made. (2) The percentage composition of the gases. (3) The weight and percentage composition of the slag.

Solution: (1) The weight of ore needed is that necessary to supply 93 parts (100-4-3) of iron in the pig iron. This will require $93 \times \frac{160}{112} = 133$ parts of Fe_2O_3 , which will be contained in $133 \div 0.90 = 148$ parts of ore.

The weight of charcoal needed is that necessary to furnish enough fixed carbon to reduce the iron oxide and that silica which is reduced, and to supply the carbon in the pig iron. These quantities are:

Reduction of Fe_2O_3 :	$93 \times 36/112 = 29.9$
Reduction of SiO_2 :	$3 \times 24/28 = 2.6$
For carbon dissolved:	 4.0
Total requirement	 = 36.5
Charcoal required	$36.5/0.90$ = 40.6

The weight of flux required is best found by calling it x, and then figuring out the slag, as follows:

Silica in the slag will be that in the ore, flux and fuel, minus that reduced to silicon. Therefore,

In ore	 148	$\times 0.08 = 11.8$
In flux	 x	$\times 0.02 = 0.02 x$
In fuel	 40.6	$\times 0.02 = 0.8$

$$\text{Reduced} \dots\dots 3 \times 60/28 = 6.4$$

$$\text{Silica in slag} \dots\dots\dots = 6.2 + 0.02 x$$

By similar calculations we find the slag to contain, as a whole,

Silica	 6.2 + 0.02 x
Alumina	 3.4
Lime	 0.50 x
Magnesia	 0.04 x
Alkalies	 0.4

$$\text{Total weight} \dots\dots\dots 10.0 + 0.56 x$$

If 65% of the slag is to be silica and alumina together, then

$$0.65 (10.0 + 0.56x) = 9.6 + 0.02x$$

from which $x = 9$.

The above solution is perfectly general, and applies to all kinds of ore, flux and fuel, and the production of any desired kind of slag.

(2) The gases will contain the fixed carbon of the charcoal (except that part which goes into the pig iron) in the state of CO, the carbonic acid driven off the flux, and the volatile matter from the charcoal. The latter may be assumed as composed of equal parts by volume of hydrogen, carbon monoxide, and carbon dioxide, which would correspond to weights of those gases in the proportion of 2:28:44. The gases passing off will therefore be, in parts by weight,

CO from fixed carbon : $32.5 \times 28/12 = 75.8$	}	76.8
CO from volatile matter : $2.7 \times 28/74 = 1.0$		
CO ₂ from volatile matter : $2.7 \times 44/74 = 1.6$	}	5.6
CO ₂ from flux : $9.0 \times 0.44 = 4.0$		
H ₂ from volatile matter : $2.7 \times 2/74 = 0.1$		0.1

Total weight of gases.....82.5

Percentage composition of gases by volume,

$$\text{CO } 76.8 \div 82.5 = 61.0 = 92.4\%$$

$$\text{CO}_2 \quad 5.6 \div 82.5 = 2.8 = 4.2\%$$

$$\text{H}_2 \quad 0.1 \div 82.5 = 2.2^* = 3.4\%$$

66.0 100.0%

The volumes 61.0, 2.8 and 2.2 represent cubic meters of these gases per 100 kilograms of pig iron made; if multiplied by 16 they give the cubic feet per 100 lbs. of pig iron.

(3) The slag will contain, substituting $x = 9$:

Silica	6.4 = 42.4 %
Alumina	3.4 = 22.5 %
Lime	4.5 = 29.8 %
Magnesia	0.4 = 2.65 %
Alkalies	0.4 = 2.65 %

15.1 100.00%

COMBINED BLAST AND ELECTRICAL FURNACE.

The electrical reduction of iron ore differs radically from blast furnace practice in one essential particular, viz., that since no air is blown in, any excess of carbon above that consumed in reduction must remain unused, accumulate and eventually clog the furnace. The amount to be used as a minimum cannot, moreover, be calculated until we know how much CO₂ will be formed in reduction, and that is an unknown quantity unless arrangements are made so that none can be formed. The four following modifications of working an electrical pig iron furnace are possible, with the object in view of avoiding the accumulation of excess carbon in the crucible.

(1) A deficit of carbon may be put into the charge, thus permitting unreduced iron oxide to escape in the slag, and preventing unused carbon from accumulating. This solution leads to the disadvantages of loss of iron, heavy corrosion of lining of furnace and heavy consumption of electrode carbon. It may have the secondary result of preventing reduction of silica or taking up of carbon by the iron, and may thus furnish a metal with high melting point and approaching steel in composition. Such slag would also remove some of the phosphorus in the charge, but practically no sulphur.

(2) A charge of ore and flux without fuel may be run through the furnace whenever an accumulation of carbon occurs, as is shown by the resistance of the furnace falling off and the furnace getting cold. This was the device adopted in the experiments of the Canadian commission at Sault Ste. Marie, but while permissible in experimental work, it would not do to thus periodically derange a furnace in regular running.

(3) The fuel may be calculated only for the production of CO in the furnace, and this condition is

*We have not attempted to correct several apparent minor errors which do not materially impair the illustrative value of the example.—Ed.

Charges.	Pig Iron.	Slag.	Gases.
Ore: (148.0)			
Fe ₂ O ₃ 133.2	Fe 93.0		O 40.2
SiO ₂ 11.8	Si 3.0	SiO ₂ 5.4	O 3.4
Al ₂ O ₃ 3.0		Al ₂ O ₃ 3.0	
Limestone (9.0)			
CaO 4.5		CaO 4.5	
MgO 0.4		MgO 0.4	
SiO ₂ 0.2		SiO ₂ 0.2	
CO ₂ 4.0			CO ₂ 4.0
Charcoal: (40.6)			
Fix'd C..... 36.5	C 4.0		C 32.5
CO 1.0			CO 1.0
CO ₂ 1.6			CO ₂ 1.6
H ₂ 0.1			H ₂ 0.1
SiO ₂ 0.8		SiO ₂ 0.8	
Al ₂ O ₃ 0.4		Al ₂ O ₃ 0.4	
(NaK) ₂ O 0.4		(NaK) ₂ O 0.4	
Totals 197.9	100.0	15.1	82.8

approximated by leading off the gases from the hot part of the furnace and not allowing them to cool in contact with the ore. In this way, reduction by CO is avoided, and the fixed carbon in the charge may be consumed almost entirely to CO without formation of CO₂. This would bring the furnace consumption of carbon nearer to a definite amount and, by avoiding reduction except by solid carbon, would tend to use up all the carbon charged, the amount of which would be calculated for this manner of working (as in the numerical example worked out for illustration).

(4) The best solution of this difficulty may be to provide tuyeres by which air can be sent into the crucible of the furnace, and thus burn any accumulation of carbon. A given quantity of air will always burn a given quantity of carbon, and therefore the cure would seem to lie in having a variable supply of air, which is increased whenever the falling resistance of the furnace indicates that carbon is beginning to accumulate, and diminished to a small minimum supply, only enough to keep the tuyeres open, when the furnace is in good electrical running order. It would represent a combined electrical and blast furnace, with the blast so regulated as to overcome the chief difficulty of the purely electrical furnace—the accumulation of unused carbon in the crucible.

It may be quite possible, by some such device as Mr. Taylor's large electrical furnace, to practically combine the blast furnace and the electrical furnace. The writer is quite confident that any practicable method of introducing electrical heat into the crucible of a blast furnace will result in large economies in the furnace working. Only one-quarter of the heating power of the fuel is developed around the blast tuyeres, and yet if half of this could be replaced by electrically generated heat, an economy of 50% could in all probability be reached upon the fuel bill.

To put it into figures, it takes 1.2 tons of coke to make a ton of pig iron in the blast furnace, and about three-quarters of a ton is burnt by the blast, producing at the smelting zone about 25% of the calorific power of the coke. If electrical energy could be made to supply only one-half of this, the furnace would make iron with half the previous coke supply, that is, with 0.6 ton of coke per ton of pig iron, and this with an expenditure of electrical energy equal only to 12.5% of the calorific power of the coke, that is, equal to the calorific power of but 0.15 tons of coke.

The question of economy in this case will not be, then, the simple replacement of fuel heat energy by an equivalent amount of electrical heat energy, but the comparison of fuel heat energy with the cost of one-fourth its amount of electrical heat energy. This may be quite possible in many localities, and the combined furnace would work more regularly than a purely electrical furnace. The question awaits the coming of the electrometallurgical engineer who can make practicable the requisite combination. A possible solution may be to use cheap electrical power to super-heat

the hot blast, and thus to make the blast itself the agent for carrying electrically developed heat into the furnace.

THE BEE-HIVE COKE OVEN AS A POWER PLANT. By J. R. CAMPBELL.

Chief Chemist, H. C. Frick Coke Co., Scottdale, Pa.

In these days when the conserving of the fuel supply of this country is becoming more and more necessary, perhaps no question is of greater moment than that of utilizing the waste gases of the ordinary beehive coke oven. This seemingly waste of energy, which the sun has required many thousands of years to potentiate, is a striking feature of the American practice of coke making. In the Connells-ville region alone some 25,000 beehive coke ovens are daily throwing out of their trunnel heads, like miniature Vesuvius, millions of cubic feet of valuable gases, which would light towns and cities and develop power equal to a Niagara if properly utilized by gas engines and dynamos, to say nothing of the other valuable products of coal tar and ammonia liquor.

The European coke maker has realized all this many years ago, hence he has adopted the retort and by-product coke ovens, the former reclaiming the gases and the latter all the by-products of coke making. And we are still building the beehive coke oven or some other type embodying the same principle of coking, that is, from the heat generated by the partial combustion in the oven of the coal gases. It seems unfair to the beneficent Providence which has bestowed upon us this potential energy in the form of coal measures, one-third of which we allow to waste.

We have 25,000 beehive coke ovens in the Connells-ville region. A good many were built before a great deal was known about the valuable by-products of coke making, and we concede that it might not be profitable for the coke operator to dismantle these and construct other types. Let us not expect that, but for the present let us cast about for some method of utilizing the type we have to the best possible advantage. Let us not be content merely to follow in the footsteps of our predecessors. We have progressed in nearly everything pertaining to the ways and means of mining these black diamonds from the bowels of the earth, but when it comes to transforming them to the scintillating and sparkling gems, we have stopped one step short of complete success. *Let us take this other step.*

The writer does not claim to be a pioneer in undertaking the complete utilization of the beehive coke oven gases, but it has been his privilege to make some original investigations along this line. The step proposed may never be taken, but the suggestions here offered may serve as food for thought, or possibly to aid some other to solve the problem.

The following is an approximate analysis of coal gas as produced by distillation in a retort oven. This will be taken as a type from which all subsequent calculations and deductions will be made:

Per cent.
by volume.

Carbon dioxide (CO ₂)	2.00
Ethylene (C ₂ H ₄)	5.50
Oxygen (O ₂)	.50
Carbon monoxide (CO)	11.50
Hydrogen (H ₂)	43.50
Methane (CH ₄)	35.00
Nitrogen (N ₂)	2.00
B. T. U. per cubic foot	.610
Specific gravity	.45
Candle power	16

TOTAL CALORIFIC VALUE OF GAS FROM A SINGLE BEEHIVE
OVEN CHARGE.

Taking the weight of a cubic foot of air as 0.076 lb.
and the weight of a cubic foot of coal gas as 0.035 lb.,

in Fig. 1. The hot gases were led through this flue to a boiler plant.

Analysis of Waste Gases From a Beehive Oven.

No. of Sample.	CO ₂	O ₂	CO	H ₂	CH ₄	N ₂
1	8.60	...	2.80	4.05	1.65	82.90
2	8.60	...	2.80	8.35	1.21	79.04
3	2.40	1.20	9.00	11.10	1.25	75.05
4	2.00	1.40	7.80	10.37	1.48	76.95
5	1.80	...	10.20	16.22	0.85	70.93
6	2.80	1.80	9.40	12.50	1.00	72.50
7	2.20	...	9.20	12.60	0.80	75.20
8	3.80	...	8.40	11.85	0.85	75.10
9	3.80	0.40	6.40	15.25	1.05	73.10
10	7.00	...	1.40	4.40	0.40	86.80
11	5.00	1.00	3.40	5.92	1.35	83.33

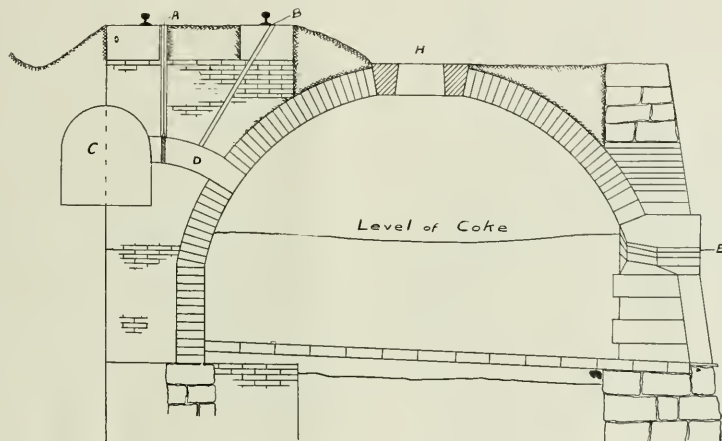


Fig. 1—Sketch Showing Arrangement of Coke Oven.

one ton of a typical coking coal will yield 400 lb. or 11.429 cu. ft. of gas. Using round numbers to simplify the calculation we have:

Gas generated by 1 ton of coal	11,000 cu. ft.
Average charge per oven	7 tons
Duration of coking process	50 hrs.
Gas generated by 1 oven per hr.	1,540 cu. ft.
Calorific power per hour	939,400 B. T. U.

This is approximately equivalent to 25 hp. per hour for 1 oven.

The above value is obviously the theoretical amount of heat derivable from the waste gases from a typical beehive oven charge. As the process of coking is now generally conducted all of this heat and heating power is wasted, except the small amount of heat used in supporting the distillation of the coal. No system of coke making can prevent waste entirely, but a large proportion of this waste may and ought to be prevented in the beehive process.

A consideration of the following analyses will give some idea of the losses and possible economy of a beehive oven. The gas samples were taken from an oven which had connection with a waste heat flue as shown

12	6.40	1.40	6.80	0.60	84.80
13	3.20	15.50	...	1.20	80.10
14	5.00	12.20	...	1.95	80.85
15	5.30	1.40	1.20	8.15	83.55
16	10.20	0.40	...	1.90	87.50

Sample No. 1.—Taken at trunnel head, 30 minutes after charge ignited. There was a large opening over the door at E, and the oven was giving off smoke.

Sample No. 2.—Taken on same oven as Sample No. 1, at trunnel head, after oven had been burning about 2 hours. No charge had been made in the airing, but the analysis shows more hydrogen.

Samples Nos. 3 and 4.—Taken at trunnel head after oven had been burning about 15 hours. The air supply to the oven was diminished. A little oxygen shows up in analysis due to rather careless methods in sampling. This statement holds true in several other instances unless otherwise accounted for.

Sample No. 5.—Also taken at trunnel head after about 15 hours. Particular attention was given the airing of the oven, which was such that the best conditions prevailed for the coking process. An ex-

perienced man had given his individual attention to the oven for several hours to secure exact conditions.

Sample No. 6.—The conditions under which this sample was taken will be understood by referring again to Fig. 1. A damper was put over the trunnel head, H, and damper, A, removed, thus forcing the gases into the main waste heat flue, C, through the short connecting flue, D. Sample was taken through damper, A, after oven had burned about 15 hours.

Sample No. 7.—This sample was taken under the same conditions as the preceding save on another day, as a check, since considerable oxygen showed up in first. More care was taken with this sample.

Sample No. 8.—Taken from trunnel head 36 hours after charge ignited, on 48 hr. coke. The oven door was luted up until only a mere crack remained for the air to enter.

Sample No. 9.—Taken under same conditions as preceding, 48 hours after charge ignited, on 72 hr. coke.

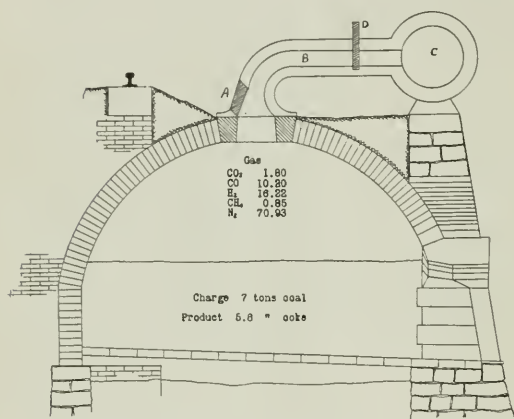


Fig. 2—Sketch Showing Suggested Arrangement for Complete Utilization of Waste Products.

Sample No. 10.—Taken under the conditions of Sample No. 6, about 3 hours before drawing coke. All gases were practically expelled, hence the small amount of air admitted was almost sufficient to complete combustion.

Sample No. 11.—Taken in main flue at boilers. As has been stated with reference to the waste heat system, the gases from the individual oven are conducted by a short flue into a main waste heat flue which leads under the boiler. If the conditions are as intended the compositions of the gases at this point should be the same as at the trunnel head or junction of the short flue with the main flue, since it is the intention to use damper, A, in Fig. 1, while the oven is out or being charged. The analysis would indicate leaks all along the main waste flue, which cool the gases but cause slow oxidation. It could hardly be called combustion since the gases are already surcharged with black damp (CO₂), which would smother or at least retard combustion.

Once combustion is started it should be completed then and there to obtain the maximum results.

Sample No. 12.—Same as Sample No. 11, but on a different day—to check the hypothesis that there were leaks along main flue.

Samples Nos. 13 and 14.—Chimney gases. These analyses show that excessive quantities of air comingled with the oven gases at and above the point where they played upon the boiler tubes. This is exceedingly bad practice.

At this point in the investigations the writer made some deductions: first, that the gases used in the waste heat system and coming off naturally in the coking process, were in a state of partial combustion; second, that it would be impossible to carry on the coking processes if this combustion be made complete in the dome of the coke oven; third, that there must be lost efficiency from the coke oven in this form of a power plant by the way in which it was conducted.

Under this last head it was ascertained that each oven was developing only about 15 hp. which seemed far below the maximum possibility.

Then the writer conceived the plan of the air duct leading into the short connecting-flue, and proceeded to work along this line. Fig. 1 shows the air duct at B. It was the aim to have this duct arranged in such a manner that only heated air should be allowed to enter the short flue. It is understood that a stack is employed in this waste heat system to give a draft so that no difficulty was encountered in getting the air duct to work. In some cases trouble has been experienced in getting material refractory enough to withstand the excessive heat of this short flue, in which case cold air might be better than heated air as the temperature would be lowered somewhat and the combustion thrown out into the main flue.

Samples Nos. 15 and 16 were taken from experiments with this airing device. The conditions were otherwise the same as those under which Samples 6 and 7 were taken.

Sample No. 15.—Taken through damper, A, in Fig. 1. Air was allowed to enter short flue by means of the duct, B. The oven had burned about 18 hours. It is noted that the combustion was not complete, since there was still an insufficient supply of air.

Sample No. 16.—Taken under the conditions of Sample No. 15, save that more air was permitted to enter through duct. The combustion is not ideal but it approximates the total combustion without an excess of air.

In such a scheme for the modification of the present system of utilizing the waste heat system, the underlying principle is that the gases should be burned completely, and as close to the oven as possible, in order to obtain the maximum efficiency of the coke oven as a power plant. At present the writer is not in a position to say what the increased efficiency will be, but the idea is being developed and pushed rapidly. In this scheme there must not be any leaks along the line or at the boilers nor loss by radiation. The pres-

ent practice, as regards the last point, is good, since the waste heat flues are buried in the earth to a depth of several feet. There are a few power plants of this description in the Connellsville region and it is earnestly to be hoped that they will be made a complete success and will be one big step toward the conservation of the valuable fuel supply. It is not to be concluded that a whole coke plant could be harnessed in this way for there would be no means of utilizing all the power.

THE BEEHIVE COKE OVEN AS A PRODUCER GAS PLANT.

Attention is directed to the following analysis of a producer gas:

By volume.

Carbon dioxide (CO ₂).....	6.00
Carbon monoxide (CO).....	22.00
Hydrogen (H ₂)	11.00
Methane (CH ₄)	3.00
Nitrogen (N ₂)	58.00

By reference to any of the oven gases at different stages of the coking process, except those that have been purposely oxidized, it will be seen that there is a marked similarity. And there is so much of it escaping into the atmosphere daily that it might prove profitable to utilize this gas in suitable gas engines direct. This would dispense with expensive boiler equipments and develop power enough to run all the machinery about a combined coal mining and coke making plant, as well as serving to generate electricity for lighting neighboring towns and other purposes. The gases could be conducted directly from the trunnel heads of the ovens into chambers, cooled by water and pumped into large gasometers ready for consumption in gas engines. Then again the gases might be freed from CO₂ by some process of scrubbing and thus rendered more explosive.

Enough gas could be collected while the oven was at its best, as a gas producer, and the balance of the time operated as a straight beehive oven with open trunnel. This would not be many hours, for all the analyses show producer gas down almost to the last ditch.

If the scheme could be made feasible and commercial then this last step to the complete utilization of the otherwise waste products of a beehive coke oven would be made.

In Fig. 2 a rough draft of the idea is shown. C is a large gas main which leads to a gasometer. B is a connecting main which leads the gas from the trunnel. A is a damper for closing the charging door, and D is a damper for closing the gas conduit. The producer gas shown in crown of oven is the best the analyses show, but the writer is of the opinion that with due attention to the airing as was given in this particular case, this same high quality of producer oven gas could be maintained throughout the coking process.

The writer is making preparations to continue investigations of this phase of the beehive process. They may lead to naught. The contents of this last discus-

sion may simply outline his observations and impressions on this subject as they were presented. At the outset it was represented by coke men who professed to know that the gases from a coke oven were in a state of complete combustion and in such a state were fit only to be conducted in a highly heated condition to boilers and the heat abstracted according to the system in vogue in the Connellsville region. That contention is disproven at least.

RESUME.

The following conclusions are offered: First, the beehive coke oven, as a power plant operated along waste heat lines, ought to develop 25 hp. per hour; second, this efficiency is not maintained on account of mistaken ideas in the construction and operation of the waste heat systems due to imperfect knowledge of the nature of oven gases and their proper combustion; third, there are possibilities in the beehive coke oven as a power plant from the standpoint of a producer gas proposition.

THE DETINNING OF TIN SCRAP AND ITS COMMERCIAL IMPORTANCE.¹

By CARL GOLDSCHMIDT.

The art of plating sheet iron with a light covering of tin, and thereby forming a material, which possesses the valuable properties of iron, as well as of tin, has long been known. It was practiced at the end of the Middle Age, in the Bohemian mountains, and was transplanted from there, at the beginning of the seventeenth century, to Saxony. About 100 years later, it was taken to Wales, but only developed there within the last century, into a large industry. Since the middle of the last century, the making of tin-plate has constituted one of the main industries of England, the production in the last few years, amounting to about 650,000 tons. The tin-plate industry in America began during the last decade, and here also it has obtained a similar importance, the production during the last year amounting to about 500,000 tons.

In comparison with this large output, the production of other countries is small; Germany for instance produced only 60,000 tons of tin-plate.

Since the beginning of the enlargement of this industry, i. e., since the middle of the last century, the problem of utilizing the tin scrap, which is obtained from the manufacture of tin cans and tin-plate articles in general, has required investigation. This scrap could not be used directly in the open hearth process on account of its tin contents. The problem was, therefore, to separate the tin from the iron, which appeared to be very simple and to promise reward, as the tin scrap could at that time be obtained gratis from the can factories.

Even as late as the early eighties, when experiments were made on a larger scale at the Goldschmidt Works in Berlin, the tin scrap was furnished them free of charge and the owners of the tin plate factories even paid the cost of transportation.

¹ Translated from *Zeits. angew. Chem.*, January, 1909.

Although the problem seemed to be worth the while, and full of possibilities to the chemist, it required a lifetime of hard labor and perseverance to find an available method in which the products obtained would pay for the necessary reagents and time. The literature on this subject is very extensive, hundreds of patents were obtained, but only a few were brought into use. For example, one American obtained sixteen patents, with 389 claims.

Mechanical processes of extracting the tin by melting, were not considered at all, as this is done as far as possible by the tin plate manufacturer. Furthermore, methods of dissolving the tin by purely chemical processes, such as solution in acids or alkalies, did not seem at first to promise practical success. The acids attacked not only the tin but also the iron, and it was found too expensive to recover the tin from the resulting solution. The alkalies, used alone, or with oxidizing agents, such as compressed air, salt-peter, lead oxide, etc., did not attack the iron, but they also extracted only a small portion of the tin and in such a form that it could only be recovered at a great expense.

Finally, it seemed, that a method using chlorine would solve the problem of extracting tin from the tin scrap, but this method soon disappeared from practice and only very recently was it taken up again. The details of this method will be described below. The cheap production of electricity has offered many possibilities for electrochemical processes, among which is an electrochemical process for detinning. As early as 1882, the firm of Theodor Goldschmidt made experiments in this line, using the tin scrap as the anode and iron plates as the cathode. An artificially heated solution of caustic soda was used as the electrolyte. While the laboratory experiments were simple, the conditions in practice proved very complicated. Electrochemical and mechanical difficulties had to be overcome, and were solved at different factories, in different ways. The process itself can be described in an elementary way, leaving the modern ionic theory out of consideration, by saying that the electric current decomposes the water, forming oxygen at the anode, which transforms the tin into tin oxide. This oxide dissolves in the excess of caustic soda to form sodium stannate, while hydrogen is developed at the cathode, and this in turn precipitates the tin on the cathode. The presence of free caustic soda is therefore a fundamental requirement of the process. But caustic soda continually absorbs carbonic acid from the air, forming sodium carbonate. More tin is dissolved from the anode than is deposited on the cathode, owing to the much greater surface of the former compared with the latter. The free caustic soda has, therefore, a tendency to gradually disappear and the electrolyte thus becomes ineffective. It is, therefore, necessary to maintain a certain excess of free caustic soda. If this excess becomes too small the tin is only partly dissolved, and not only is the tin output reduced, but the quality of the steel for which the detinned residues are used is bad.

Besides these purely chemical difficulties, electrochemical problems have to be considered. The efficiency of the electrolytic bath depends upon the proper heating of the electrolyte. In heating the cells, care must also be taken to prevent short circuits.

The tin scrap is always placed in a basket connected with the positive pole. The construction of this basket involves considerable difficulty. It must be of moderate size, since otherwise the tin scrap in the center would not be acted upon. Furthermore, the tin scrap is rather voluminous and cannot be used in compressed form, since the electrolyte should have free access to all surfaces. This means a small weight of tin scrap per basket, and therefore considerable expense for labor.

Only by very careful working and by giving continual attention to the right composition of the electrolyte, is it possible to remove the tin so perfectly from the sheet iron that the latter can be sold to open-hearth plants. Even with very careful working, there will remain 0.05 to 0.1 per cent. of tin on the iron. Even when very careful attention is given to the filling of the baskets, some parts of the scrap adhere to each other so closely that the electrolyte cannot come in contact with them at all; furthermore, the lower edges of the tin plates, which are covered with a thicker tin layer, are scarcely attacked.

From this it will be seen that it is not possible to obtain a perfect product, yet by very careful manipulation, a material containing 0.1 to 0.2 per cent. of tin, can be obtained, which is suitable for open-hearth use. Of course, such a product can be obtained only by taking the strictest care and often scrap containing 0.3 to 0.5 per cent. tin is found.

The tin is obtained on the cathode in the form of a spongy deposit, which may be easily removed and remelted to salable form. The process offers considerable advantage; *first*, a useful iron scrap is obtained at one operation, which can be pressed into suitable packages by proper mechanical devices; *second*, a tin mud is produced, which can be remelted to block tin. These features and the seeming simplicity of this process, have advanced its practical utilization and until very lately no other process could compete with it.

The weak points of the above process are the necessity for careful attendance, employment of small units (which means high wages) and a considerable loss of tin. The loss of tin is due to the fact that when the detinned iron scrap is taken from the cells, a great quantity of the electrolyte, which is rich in tin, adheres to the surface. As the surface of tin scrap, treated each day in the Goldschmidt works in Essen, covers an area of not less than $12\frac{1}{2}$ acres, the quantity of electrolyte lost daily is quite considerable, even if only a small amount of electrolyte adheres to the surface. By washing with water, a tin-bearing precipitate is obtained having very little value.

Further, a certain quantity of solder remains in the tin scrap. The solid tin obtained by remelting the

spongy tin cathodes is only 97 to 98 per cent. pure, as some contamination by lead from this solder can not be avoided, even when great care is taken.

These difficulties which are fundamental to the process made it advisable to establish a different method. While the electrolytic detinning industry became possible 25 years ago, with the advent of cheap sources of the electric current, the chlorine detinning industry is the result of the coming of cheap electrolytic chlorine and the possibility of liquefying it. In the middle of the last century, Higgins (English patent 756, 1854), later Parmelee (U. S. patent 102,148, 1870), Seely (U. S. patent 127,375, 1872), and Panton (U. S. patent 135,578, 1873), attempted to detin scrap with chlorine. It was early recognized that dry chlorine gas was necessary. Dry chlorine gas combines with tin with the evolution of considerable heat, forming anhydrous tin tetrachloride, a heavy fuming liquid. This was known to Libavius as early as 1605, and has been obtainable since that time under the name of Liquor Fumans Libavii. If dry chlorine gas is carried over and through tin scrap, the chlorine and tin combine, forming tin tetrachloride, which drops off. Dry chlorine does not attack the iron at a low temperature. The process is, therefore, very simple, yet it has required more than fifty years to reduce it to a commercial basis.

The difficulties encountered at the start were manifold. Methods had to be developed to cheaply produce and ship chlorine. After treatment with chlorine, the surface of the scrap is covered with a film of a fuming and very obnoxious fluid, which has a bad effect on the eyes and nostrils of the attendants. The removal of this film was absolutely necessary; but the use of water for washing was precluded, since a solution of tin tetrachloride attacks the iron so that both the iron and the tetrachloride become useless for commercial applications. Even if the anhydrous tin tetrachloride is removed, the iron will quickly rust, rendering it comparatively worthless.

The process of detinning with chlorine was not practically applied until the beginning of the eighties, when Lambotte erected a large plant in Brussels. He used a shaft furnace through which the tin scrap is carried downward from above, while chlorine gas, diluted with air, is introduced at the bottom (German patent 32,517, 1884). The chlorine combined with the tin and the air carried the tin tetrachloride into a condensing apparatus. The detinned iron-scrap bundles were removed from the bottom of the furnace and pressed into packages ready to be sent to the steel works.

The chief difficulty of this process was that the iron scrap was exceedingly liable to rust, as was the case with all former processes of detinning with chlorine. Even if all moisture was carefully avoided and the resulting steel-gray iron stored in a very dry place, it would rust in a day. The reason for the rusting was found in the fact that the chlorine does slightly attack iron, forming a very thin invisible film of anhy-

drous ferric chloride on its surface. If the iron is exposed to air, the anhydrous ferric chloride will absorb water, and rusting results. The ferric-chloride is reduced by the iron to ferrous chloride, and this attracts oxygen and water from the air, forming oxy-chloride; this is again reduced by the iron forming rust, etc. When this fact had been established, the corrosion of the iron was prevented by removing the ferric-chloride film by a washing process (German patent 176,457).

As the result of this study of conditions, the continuous process was established. As mentioned before, the tin scrap must be dry and also free from all organic substances; paper, lacquer, etc. It is necessary to remove not only any adhering moisture, but anything that can form water. Tin tetrachloride is a substance which attracts water with great avidity and carburizes organic substances. The tin scrap is compressed into bundles (in which form they are later sold to the open-hearth steel works) and placed in the cylinders, which are then closed, after which chlorine gas is introduced. An undue rise of temperature must be prevented and considerable heat (over 1,000 cal.) is developed by the union of chlorine and tin; artificial cooling must be provided. To detin the scrap completely, it is necessary to use the chlorine at a pressure of several atmospheres, so that it enters all crevices. When the gaseous chlorine forms liquid tin tetrachloride the pressure is reduced. As long as the pressure continues to drop, detinning takes place. When the pressure remains constant for some time it is evident that the chlorine is no longer combining with tin and hence this is a sure indication that the detinning operation is completed. The chlorine and tin tetrachloride are removed, the iron scrap bundles are carefully washed, and are then ready for delivery to the open-hearth steel works. The chief advantage of the chlorine detinning process over the electrolytic process is, that there is very little expense for attendance, since the scrap is handled in large bundles. Its other good features are that the process is completed in one single operation, the tin tetrachloride is a valuable product on account of its use in silk mills. The iron is detinned by this process more completely than by the electrolytic process and finally no tin is lost in washing.

By working under pressure, the chlorine finds access to those plates which adhere closely to each other, and consequently the so-called white spots, or parts which resist detinning, only appear very seldom and then in such a small proportion as not to injure the quality of the detinned scrap. Since the iron is covered on each side with about one per cent of tin, even if one per cent of the surface is not detinned, only 0.02 per cent of tin would remain in the detinned iron.

With respect to the analysis of detinned iron, chemists are liable to make the mistake of using too small quantities. By analyzing 10 grams it is possible to find no tin, while the iron surfaces may contain a great quantity of tin at other points. To obtain a good

average sample the practice in the Goldschmidt works is to dissolve 3 kilos in hydrochloric acid, the result is considered satisfactory, only when the analysis gives considerably less than 0.1 per cent tin.

Formerly only the scrap from the tin-can factories was detinned. This was a very pure starting material for the detinning process. But with the growth of the detinning industry, the demand for such tin scrap has become greater than the supply, and while such scrap could be obtained for nothing, twenty years ago, it is now rather expensive. Naturally, many attempts have been made to make old tin cans available for detinning, but great difficulties arose. The cans contained foreign and organic matter, such as eatables, and paper labels. The solder is composed partly of lead, and thin rubber rings are placed in the folds or joints to make the can light. Furthermore, the cans are very voluminous. In order to make this material available for the detinning process, it is necessary to reduce the volume, to clean them, to remove the solder and to destroy the rubber rings. Since the material is of small value, the expense of this preliminary treatment must be low. The following method has been found practical. The cans are first compressed and, by means of rolls armed with sharp cutting points, they are punctured with a great many holes and cuts (German patent 181,876). They are then washed with a caustic soda solution, so as to remove any fat and other organic impurities. Next they are washed in pure water and the solder and rubber rings are removed by heat in a furnace. The tin cans being now pure iron and tin, are compressed into bundles for detinning (German patent 176,456 and 188,018).

Other purification methods which were suggested at different times, eliminated the washing process and only heated the cans to remove the solder. They are not to be recommended as the organic impurities are not entirely burned and form a choke film on some parts of the cans, which prevents the penetration of the detinning agent. It is therefore necessary to have the cans perfectly clean in order to obtain a good quality of iron and a proper yield of tin.

As far as the commercial part of the detinning industry is concerned, it should be stated, that tin scrap has been duty-free in Germany, since 1870; while a duty of 5 silver groschen per 100 kg. is placed on raw iron and shot. In the petition against a duty on tin scrap, the following argument was presented: The detinning industry which uses an almost worthless material, to obtain a valuable product, has not been able to increase, according to its importance, on account of the scarcity of tin scrap in Germany. It must, therefore, import such scrap from other countries, especially from the seaports of France, England and Holland, where the manufacture of tin cans for the export of all kinds of preserves, fish, etc., yields large quantities of tin scrap. But the duty of 5 silver groschen makes this material too expensive. Hence the petition to place tin scrap among "duty-free" articles arose.

It required a half century to surmount the technical difficulties, and to place the detinning industry upon a commercial footing. After this, the industry spread rapidly and soon extended its demand for raw material to other countries. At present, tin scrap is transported from all parts of the world to Germany, where the detinned scrap finds a home market. Three-fourths to four-fifths of the tin scrap in Germany comes from foreign countries and it may seem surprising that such a cheap article could stand high freight rates. Italy sends sardine boxes; Egypt, cigarette boxes; Newfoundland, lobster cans; Norway, fish cans; Switzerland, condensed milk cans; etc. To detin the scrap at these places, would not pay, because the quantity of available scrap is generally insufficient, furthermore, the detinned iron would have to be shipped anyhow to the steel works, and it weighs only 2 per cent less than the tin scrap. It is, therefore, more practical to transport the tin scrap, rather than the detinned iron; and as the location of the German detinning work is situated on the lower Rhine, it offers special advantages for low freight rates; moreover, shot yielded a higher price in Germany than in other countries, for instance, England. It is to be regretted that the favorable conditions which have prevailed so far in Germany ceased, as detinned scrap has recently reached a higher market value in England. While formerly the Goldschmidt works were able to obtain better prices for detinned scrap in Germany than in England, about four marks more per 1,000 kg., the conditions have been reversed since the latter part of 1906. At that time the difference was one mark per ton. In the beginning of 1907 it amounted to two marks, in the latter part of 1907, three marks, and during 1908, eight to ten marks.

Although the conditions are again improving slightly in Germany, the difference in the value of detinned scrap is still much lower than in England, and it would be regrettable if the continuation of such conditions should force this industry, which was born in Germany, to be transplanted to a foreign country.

As iron scrap and raw iron are generally cheaper in England than in Germany, the high valuation of detinned scrap by the English steel works in comparison to the German works, is to be explained from the fact that the English works buy independently from each other, while the German works have formed a combination and have cut the price. Furthermore, the detinned scrap has lost much of its reputation as it happened at times that some of the smaller works placed a poorly detinned material on the market.

The detinning industry of Germany treats about 75,000 tons of tin scrap per year. Of this, 50,000 tons are detinned in the Goldschmidt works in Essen, and the balance of 25,000 tons in eight or ten smaller works. Small works are, however, hardly commercial and their troubles are increasing as they have to use the electrolytic process, which is very expensive if carried out on a small scale. Their chances are now very

limited, as they have to compete with the chlorine process.

The 75,000 tons of tin scrap which are detinned every year in Germany yield about 1,500 tons of tin and tin salts, which represents about 10 per cent of the total amount consumed in Germany. In other European countries, somewhat over 25,000 tons of tin scrap are detinned yearly, and in the United States about 60,000 tons. The total consumption for the world is therefore 160,000 tons of tin scrap, containing 3,000 to 3,500 tons of tin, which is $3\frac{1}{2}$ per cent of the total yearly output of tin. When the treatment of old tin cans will assume greater proportions, the output of the detinning works will, of course, greatly increase.

When it is considered that the utilization of old cans has only been started, and that after the technical difficulties have been overcome, and the collection of cans from the dump places and from the households will be effected, the amount of available old cans will reach a value which will exceed all expectations.

Also, after the difficulties of the preliminary preparations of old tin plate material and tin cans for the detinning process have been solved, it may further be assumed that other iron scrap, for instance, from galvanized and enameled articles, can be prepared in a similar way for the iron and steel works. As the scarcity of iron ores increases, more importance will be attached to other sources of iron supply for the iron and steel works. The detinning industry is therefore not so unimportant for the steel industry, although the quantity of iron which is furnished from detinned scrap is at present comparatively insignificant.

In a paper read before the Faraday Society, Mr. Ashcroft stated that in most cases an electro-chemical industry only becomes economical when the price of power has been reduced below a certain point, which varies more or less for each electro-chemical industry. Some industries, such as the smelting of iron and the manufacture of lime nitrogen, to be worked commercially, will require a supply of energy at a cost of about \$10 for the kw. year, and this low grade limit, in the opinion of the author, could only be obtained from water powers, at which natural conditions enable the development and regulation of power at a very low expenditure of capital. The number of powers of this class are not very numerous.

What are designated as "low-resistance pyrometers" have, during the last few years, come widely into use. They are the logical outcome of the discovery that, while thermo-couples of certain alloys of base metals will not maintain their e. m. f., and, in some cases, not even withstand the physical and chemical assault of the very high heats that the platinum-rhodium couples will meet, they will, nevertheless, withstand the more moderate heats when such base metal couples are constructed with elements of large cross section.

GASES RESULTING FROM THE USE OF HIGH EXPLOSIVES.

W. Cullen describes some experiments in the *Journal of the Chemical, Metallurgical, and Mining Society of South Africa*, which he made to determine the gases resulting from the use of high explosives. He found that the gases evolved by modern blasting gelatin, in steel bombs, approximate closely to the theoretical; name, a mixture of carbon dioxide, nitrogen and water vapor. Mr. Cullen also collected and analyzed a large number of samples of mine air immediately before and after blasting, in order to determine if carbon monoxide was also formed as has been stated. In either case, carbon monoxide was found in dangerous quantity. A considerable quantity of carbon monoxide was also generated by the burning of the fuse, 96 ft. of which was generally required for each blast. The electric firing is therefore preferable. Experiments in tamping show that a slight improvement was caused by the use of clay in place of sand.

Prof. C. E. A. Winslow of the Massachusetts Institute of Technology proposes the following method for determining the number of dust particles in the air. A measured volume of air is drawn through a filter of granulated sugar, the grains of which may vary between .25 and 1 mm. in diameter. The layer of sugar should be 2 cm. deep and may be held in a glass tube of 1 to 2 cm. bore, by a perforated stopper and a square of bolting cloth. The air sample should be collected rapidly, which may be done by the use of a suction cylinder of metal with a closely fitting piston. After sampling, the sugar is dissolved, in 5 to 10 cc. of distilled water. After thorough agitation, 1 cc. of the resulting suspension of dust in water is placed in a Sedgwick-Rafter counting cell, such as is used in the microscopical examination of drinking water. The general method used in enumerating the dust particles is that described in Whipple's "Microscopy of Drinking Water," and involves simply the counting of the number of dust particles in a certain number of representative squares, and the calculation of the number originally present in the filtered air.

Nitric acid is one of the very oldest known acids. Geber, an alchemist of the eighth century, describes its production by distilling potassium nitrate (or saltpeter) with copper sulphate and alum. Another Raymond Lullius, in the thirteenth century, prepared it by distilling nitrate of potash with sulphate of iron, and Glauber, a little while afterwards, obtained it by distilling nitrate of potash with sulphuric acid or "oil of vitriol." This process is the one which, for all practical purposes, is employed now, sodium nitrate, or "Chile saltpeter," being substituted for the less common nitrate of potash. Nitric acid of 1.375 sp. gr. was sold in England in 1771 for 57 cts. a pound, being known as Gilder's aqua fortis, or strong water, because it attacked all the common metals except gold and platinum.



THE VALUATION OF PAINTS.

LINSEED OIL.

Written for THE CHEMICAL ENGINEER.

(Continued from the March, 1909, issue.)

The principal adulterants used with linseed oil are rosin oil, rosin, mineral oils, very rarely corn oil, cottonseed oil and menhaden or fish oil. The presence of any of these may be detected by the following tests:

- (1) Specific Gravity.
- (2) Flash Test.
- (3) Spot Test.
- (4) Lieberman-Storch Test.
- (5) Halphen Test.

Specific Gravity.—This may be taken by any convenient and sufficiently delicate means. The Westphal balance will be found excellent for this purpose.

As the specific gravity is compared with figures obtained at 15.5° C. (60° F.) it is necessary to make the determination at this temperature or, what is more convenient, at room temperature and calculate to specific gravity at 15.5° C. by using the following corrections, adding when the observed temperature is above 15.5° C. (60° F.) and subtracting when it is below:

Correction for 1° F. = 0.00036

Correction for 1° C. = 0.00065

Table I, below, shows the specific gravity of the various oils.

TABLE I OF SPECIFIC GRAVITY OF VARIOUS MATERIALS USED IN PAINT VEHICLES.

Material.	Specific Gravity at 15.5° C.
Benzol	0.680-0.705
Benzine	0.725-0.735
Turpentine	0.862-0.870
Cottonseed oil	0.922-0.925
Corn or maize oil.....	0.922-0.925
Menhaden or fish oil.....	0.927-0.933
Linseed oil—raw	0.932-0.935
Linseed oil—boiled	0.936-0.938
Tung or Chinese wood oil.....	0.936-0.943
Rosin oil	0.970-0.990

From this table it will be seen that low specific gravity indicates adulteration with mineral oils, cottonseed oil or corn oil, while a high specific gravity indicates Tung oil, rosin or rosin oil.

Flash Test.—A simple apparatus for carrying out the flash and fire test is shown in Fig. 1 and consists of a No. 2 porcelain crucible, the bottom of which fits into a round hole made in a piece of 3/16 inch asbes-

tos board, four or five inches square. The asbestos board rests upon a tripod. The oil to be tested is placed in the crucible, a thermometer inserted until the bulb is just covered by the oil, and heat applied from a Bunsen burner playing directly upon the bottom of the crucible. The flame is so regulated that the temperature rises 2° F. per minute. A piece of glass tubing is drawn out to a fine opening and connected with the gas jet by a piece of rubber tubing. The gas is turned on and lit at the small opening. The flame should be very small. This is passed across the surface of the liquid every minute, after the bunsen burner is placed in the crucible, until the oil flashes.

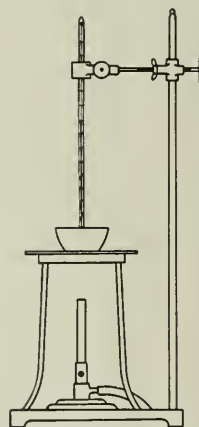


Fig. 1.

The temperature at which it begins to do this is the "flash test."

Table II gives the flash point of some oils, etc., used in the paint trade.

TABLE II FLASH POINT OF OILS USED IN PAINT VEHICLES.

Oil.	Flash Point °C.
Benzine	very low
Benzol	very low
Rosin	80-140
Mineral—about	150
Corn oil	245-250
Cottonseed oil	238-360
Linseed oil, raw.....	290-300
Linseed oil, boiled.....	270-280
Tung oil	280

From this table it will be seen that low flash point indicates the presence of rosin oil or mineral oil.

Spot Test.—About 20 drops of the oil are placed upon a very slightly concave watch glass over a sheet of white paper and 2 drops of concentrated sulphuric acid are added to the center of the oil globule. The following reactions take place:

If the linseed oil is pure a dark brown clot is formed, while with rosin oil or fish oil a reddish brown spot quickly forms, which in the former case retains its red tint for a long time while a peculiar scum forms over it. Mineral oils also give a scum which extends out from the surface of the acid drop. The test is a fairly reliable one in experienced hands to detect an appreciable amount of adulteration. To gain experience practice upon linseed oil adulterated with the above constituents.

To confirm the presence of fish oil by this test, rub a little of the oil vigorously in the palm of the hand. Fish oil mixtures give a characteristic fishy odor.

Halphen's Test.—This serves to detect cottonseed oil. The reagent is made by dissolving $1\frac{1}{2}$ grams of sulphur in 100 c. c. of carbon bisulphide and adding 100 c. c. of amyl alcohol. Equal volumes (about 5 c. c.) of the oil and reagent are heated, in a steam bath at first, and after the violent boiling has ceased, in a beaker of salt water kept at $105-110^{\circ}\text{C}$. for about one-half hour. If cottonseed oil is present a crimson wine coloration is produced. To detect corn oil, dilute the suspected linseed oil with four volumes of benzene, add one volume of strong nitric acid and shake. If linseed oil alone is present, the solution turns white, while with corn oil it is turned to a reddish orange.

The Liebermann-Storch Test.—This reaction is used to detect the presence of very small quantities of rosin oil or rosin dryer. Shake 2 c. c. of the oil with 5 c. c. of acetic anhydride, warming gently. Allow to cool, draw off the anhydride and test by adding one drop of sulphuric acid (1:1). A violet color (not permanent) is produced in the presence of rosin or rosin oil. Cholesterol, which might be found in linseed oil if fish oil were present as an adulterant, gives a similar color reaction.

TURPENTINE.

This is usually adulterated with benzene, benzol, kerosene, refined rosin spirits or wood turpentine and unrefined rosin spirits. In addition to the (1) specific gravity and (2) flash point described under linseed oil, (3) the boil point, (4) evaporation test, (5) the sulphuric acid number or rise in temperature with sulphuric acid, and (6) Scott's test for turpentines may be employed to detect adulterants.

A low flash test indicates benzene or benzol while low specific gravity indicates kerosene or benzene. High specific gravity indicates unrefined rosin spirits.

The Evaporation Test.—This is made by evaporating 10 c. c. in a weighed dish at a temperature of 100°C . The residue so obtained should not exceed 0.2 gram.

The Sulphuric Acid Number.—For this test there will be needed a 6 oz. beaker, wrapped with three or four thicknesses of blotting paper and standing upon a thick pad of blotting paper in a larger beaker, also a bottle of sulphuric acid (1.84 sp. gr.), a bottle of neutral oil, a sample of turpentine of known purity, a 50 c. c. and a 10 c. c. pipette, a burette and a thermometer. To carry out the determination, which should always be done with the same apparatus, proceed as follows:†

Fifty c. c. of neutral oil are accurately measured in the pipette and transferred to beaker, the temperature is noted, and 20 c. c. of 66°B . sulphuric acid (which should be of the same temperature as the oil) added slowly from the burette, the time being of no great importance so long as it be slow enough to allow the acid to run down without remaining on the sides of the burette. Now stir rapidly to maximum constant temperature. The rise will vary from 0° to 10°C ., depending upon the grade of neutral oil used. This rise is noted and kept for future reference. It is advisable not to use a neutral oil giving a rise of over 2°C .

Fifty c. c. of neutral oil are now measured as before, 10 c. c. of the suspected turpentine are added, the temperature is noted, 20 c. c. of sulphuric acid are added, and the maximum rise in temperature observed after stirring thoroughly. (The accuracy of the results depends largely on stirring correctly.) This will, of course, vary with the apparatus used, the strength of the acid, and the specific heat of the mineral oil. Each operator must determine his own factor with the materials used.

The rise in temperature due to the neutral oil is now subtracted from that due to the turpentine present. It will now be found that if 10 c. c. benzene be substituted for the 10 c. c. turpentine, the rise in temperature will be the same as with the neutral oil (or a trifle less, owing to the fact that more liquid is present). The increase in temperature then due to the benzene is 0° , and from these observations it will be seen how the percentage of turpentine in a mixture of turpentine and benzene can be readily calculated, the benzene being obtained by difference.

Below are some of the results obtained by Hall¹:

	No. I.	
50 c. c. neutral oil	}	Rise in temperature, 2° C.
Sp. gr. .845		
20 c. c. H ₂ SO ₄		
	No. II.	
50 c. c. neutral oil	}	1. Rise in temperature 54° C.
10 c. c. pure "turps"		2. Rise in temperature 53½° C.
20 c. c. H ₂ SO ₄		3. Rise in temperature 54½° c.
		Average 54°.
	No. III.	
50 c. c. neutral oil	}	Rise in temperature = 2° C.
10 c. c. benzine		
20 c. c. H ₂ SO ₄		

¹Hall: "Paints and Paint Vehicles," page 101.

Therefore, in any mixture of turpentine and benzine the rise in temperature $-2^{\circ}\text{C.} \times 1.923$ gives the percentage turpentine present with Hall's materials and apparatus.

No. IV.

50 c. c. neutral oil
 10 c. c. $\left\{ \begin{array}{l} 25\% \text{ "turps"} \\ 75\% \text{ benzine} \end{array} \right\} \text{Rise} = 14\frac{3}{4}^{\circ}\text{C.}$
 20 c. c. H_2SO_4
 $\therefore \% \text{ turpentine present} = (14\frac{3}{4}^{\circ} - 2^{\circ}) \div 1.923 = 12\frac{3}{4}\%$
 $\times 1.923 = 24.55\%$

No. V.

50 c. c. neutral oil
 10 c. c. $\left\{ \begin{array}{l} 50\% \text{ "turps"} \\ 50\% \text{ benzine} \end{array} \right\} \text{Rise} = 28^{\circ}\text{C.}$
 20 c. c. H_2SO_4
 $\therefore \% \text{ turpentine} = (28^{\circ} - 2^{\circ}) \times 1.923 = 50\%$

Hall states that with experience and proper care the percentage of turpentine can be readily obtained within one per cent of the correct value. A trial on old turpentine and distilled turpentine which had not been subjected to the action of air gave results the same as on the fresh material.

Scott's Tests for Turpentine.—This test is used to identify the various turpentines and also rosin spirit, benzine and benzol. Shake equal volumes of the turpentine to be tested and concentrated sulphurous acid until the two are thoroughly mixed. Now set aside and note the time required for the mixture to separate into two layers, and also the color of the two strata. A sample of known purity should be run alongside of the turpentine to be tested and the time and rate of shaking the samples should be as uniform as possible. The following characteristics are given by the various turpentines and adulterants of the latter:

1. *American Turpentine.*

Separation takes place very slowly.
 Upper stratum—Opaque; milk white.
 Lower stratum—Translucent; milky white.
 Odor—Slight terpene smell.

2. *Russian Turpentine.*

Quick separation.
 Upper stratum—Translucent; faint turbidity.
 Lower stratum—Clear and colorless.
 Odor—Slight pungent smell.

3. *Deadwood Turpentine.*

Medium slow separation.
 Upper stratum—Opaque; light buff color.
 Lower stratum—Translucent; yellow-amber color.
 Odor—Distinct tar smell.

4. *Liverwood Turpentine.*

Medium quick separation.
 Upper stratum—Translucent, lemon yellow color.
 Lower stratum—Clear and colorless.
 Odor—Mild tar smell.

5. *Rosin Spirit.*

Medium slow separation.

Upper stratum—Translucent; golden-yellow color.
 Lower stratum—Translucent; creamy-white color.
 Odor—Pungent rosin smell.

6. *Benzine (Petroleum Naphtha).*

Quick separation.
 Upper stratum—Clear and colorless.
 Lower stratum—Clear and colorless.
 Odor—Sulphurous smell.

7. *Benzol.*

Quick separation.
 Upper stratum—Slight turbidity; faint yellow color.
 Lower stratum—Clear and colorless.
 Odor—Benzole and sulphurous smell.

DRIERS.

Driers may contain the following metallic salts: Litharge, PbO , red lead, Pb_3O_4 , manganese dioxide, MnO_2 , manganese borate, MnB_2O_4 , and rarely zinc sulphate, ZnSO_4 , and zinc oxide, ZnO . In addition to the above metallic salts cheap driers usually contain rosin. This latter makes the dry film brittle and it dusts when scratched with a knife.

To determine the metallic salts, weigh 20-25 grams of the drier into a fairly large Erlenmeyer flask and add 15 c. c. of benzine and 15 c. c. of turpentine. Shake to mix the three liquids and then add 40 to 50 c. c. of dilute hydrochloric acid (1:1). Shake at short intervals for about an hour. Heat by placing the flask in hot water. Keep away from the flame. Whirl the contents of the flask to mix well and allow to settle. Separate the aqueous layer into a dish or casserole and wash the oily layer twice with warm water. Add the washings to the contents of the dish or casserole and evaporate the latter to dryness. Dissolve in 5 c. c. of dilute nitric acid and filter. Add 10 c. c. of sulphuric acid to the filtrate and determine lead as PbSO_4 , as directed in white paints, by evaporation to sulphur trioxide fumes. To determine manganese, use the filtrate from the lead or the solution obtained by evaporation with sulphuric acid, and, after diluting the latter with cold water, proceed as directed for manganese in "Red Paints" (see March issue, page 82). Zinc, if present, may be determined as in white paints. To detect rosin use the Libermann-Storch test.

Driers, however, are seldom analyzed as this gives little indication of their value. To determine the efficiency of a drier proceed as recommended by Job¹ in the Specifications of the Philadelphia and Reading R. R., which follow:

"The material desired consists of a pure turpentine hardener and oil drier, conforming to the following:

"1st. When equal parts by weight of the Japan and of pure turpentine are thoroughly mixed and poured over a slab of glass, which is then placed nearly vertical at a temperature of $100^{\circ}\text{Fahrenheit}$, with a free access of air, but not exposed to draught, the coating shall be hard and dry, neither brittle nor sticky, in not exceeding twelve minutes.

"2d. When thoroughly mixed with pure raw linseed oil at the ordinary temperature in proportions of 5 per cent by weight of japan to 95 per cent by weight of raw linseed oil, no curdling shall result, nor any marked separation or settling on standing.

"3d. When the above mixture is flowed over a slab of glass, which is then placed nearly vertical at a temperature of 100° Fahrenheit, with free access to air, but not exposed to draught, the coating shall dry throughout, neither brittle nor sticky, in not exceeding two hours.

"4th. When five cubic centimeters of the japan are poured into 95 cubic centimeters of pure turpentine at the ordinary temperature, and thoroughly shaken, a clear solution shall result, without residue, on standing one hour.

"5th. After evaporation of the turpentine, the solid residue must be hard and tough, and must not 'dust' when scratched with a knife.

"6th. Benzine or mineral oil of any kind will not be permitted.

"Shipments which are not closely in accordance with these specifications, or which are not of uniform quality throughout, will be returned at the expense of the shipper."

MIXED PAINTS.

A can of mixed paint should be accurately weighed and opened very carefully without shaking the contents. It very often happens that the upper portion of the can will consist of the clear vehicle, the pigment having settled to the bottom. When this is the case, the clear vehicle should be drawn off by means of a pipette and placed in a dry beaker. The remainder of the can should then be well stirred so that the vehicle and pigment are uniformly mixed. About 25 grams of this thoroughly stirred remainder is transferred to a weighed 200 c. c. beaker by means of a pipette. The pipette is washed thoroughly with benzine, allowing the washings to run into the beaker. The latter is half filled with benzine and then the rest of the way up with benzol. The contents of the beaker are next stirred well and allowed to stand until thoroughly settled. When the pigment has practically all of it settled, the solution above it is decanted into a large (1,000 c.c.) beaker. The residue remaining in the small beaker is washed four or five times with benzine by decantation, pouring the solution each time into the large beaker. Any pigment that may have passed over into the large beaker during the decanting is added to the contents of the small beaker. The latter is dried in an air bath until free from benzine, the stirring rod is brushed off into the beaker and the latter and its contents are then weighed. This, of course, represents the amount of pigment in 25 grams. By weighing the amount of vehicle drawn off and the amount of paint remaining in the can, the respective quantities of pigment and vehicle can be calculated.

When upon opening the can, the pigment and vehicle have not separated appreciably it will be found best to stir the contents of the can until the pigment and vehicle are thoroughly mixed and then place 100 grams of the paint in a tall, narrow weighed beaker, cover with a watch glass and heat to 60 to 70° C. This changes the viscosity of the oil and allows the heavier pigment to settle. After a few hours there should be a clear layer of oil above. Draw this off with a pipette, weigh and set to one side. The mixture remaining in the beaker should then be washed at first with benzine and benzol and then with benzene only four or five times as directed above, dried and weighed.

Where a centrifuge is at hand the pigment and paint may often be readily separated by means of this, using for the purpose small tin cups made to fit the

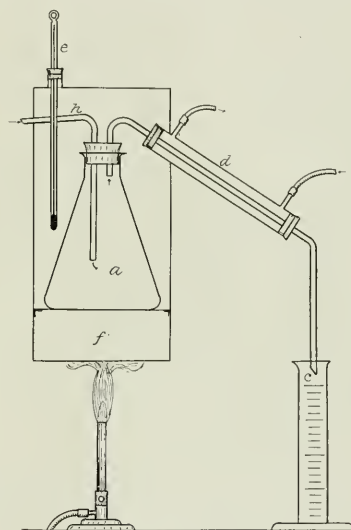


Fig. 2.

receptacle of the centrifuge. The final separation of the vehicle and pigment, even here, is, of course, to be made by washing with the solvents mentioned above.

The vehicle will consist of linseed oil, any material used to adulterate this, a dryer and sometimes thinners and water. To determine the adulterants in the linseed oil it is necessary to separate the water and thinners from this. This may be conveniently done by heating 10 to 15 c.c. of the separated vehicle in a porcelain dish at about 125° C. for three or four hours. This treatment will drive off the volatile matters and leave only the linseed oil and dryer. The linseed oil may then be tested for adulterants as directed previously.

The composition of the vehicle can be found by the use of the following apparatus and method: *Apparatus*.—This consists of a flask, *a*, closed with a 2-hole

rubber stopper. Through one of these holes is inserted a condenser, *d*, and through the other a tube, *h*, by means of which a current of coal gas is passed into the flask. The condenser dips into a glass graduate, *c*, which is divided so that it may be read to 0.1 of a c.c. The flask, *a*, is placed in an air bath, *f*, the temperature of which is controlled by means of a thermometer, *e*.

The method consists in mixing 25 grams of the paint with sufficient dry, inert pigment, like silica or sublimed lead, until it ceases to be pasty and then transferred to the flask by means of a cone of glazed paper. The apparatus is connected as shown and the temperature of the oven is kept at 110 to 120° C. until no more distillate comes over. If any water is present in the paint it will be found in a layer at the bottom of the graduated cylinder, while any benzene will be found on top. The temperature is then gradually increased to 175° C., collecting any distillate that may come over, and kept at this temperature until no further distillate appears. The volume which is distilled between the temperature of 120 and 125° C. is then recorded as turpentine.

In place of making the determination by volume a weighed quantity of paint may be used. The weight of the water and benzene may be taken together. The weight of the water can, of course, be calculated from the volume which it occupies. The difference will give the weight of benzene. The weight of turpentine can then be found on further distillation and the linseed oil can be determined by difference.

We now have from the above the percentage of paint and the percentage of vehicle, also the percentage of linseed oil, of water, of benzene and of turpentine in the vehicle.

PRACTICAL TESTING OF PAINTS.

This test is usually made to determine the covering power of the paint and its durability. To determine the covering power the method recommended by Mr. G. W. Thompson, chemist of the National Lead Co., will give excellent results. For this test use white pine boards, 30 in. long by 10 in. wide, and approximately 1 in. thick. Each end of the board is provided with a cleat having a tongue fitting into a groove on the end of the board and securely nailed on. The entire board, including the cleats, is to be finished to the size given above. Three of these boards are primed with, we will say, the following paint mixture: White lead paste, 100 lb.; linseed oil, one-third boiled, 75 lb. No attempt is made to secure a definite amount of priming paint to the unit of surface; this for the reason that the boards may vary considerably in their absorptive power. When this priming coat is dry each board receives a diagonal stripe of lampblack in japan about 1 in. wide on one or both sides of the board, as may be desired. When this black stripe is dry it is given a second coat of paint mixed to a consistency proper for painting, the formula being recorded. The weight per gallon of the paint so mixed is then ob-

tained by finding its specific gravity and multiplying by 8.33, which gives the weight per gallon. Inasmuch as the board which we are using has a total surface of 680 sq. in., all we have to do is to find what the ratio is between 780 sq. in. and the spreading rate at which we desire to apply the paint in order to find the fraction of the gallon which we wish to apply to each board. If the rate adopted is 1,200 sq. ft. to the gallon, then we get the formula: 680 sq. in. : 1,200 sq. ft. :: 1 : x, the reciprocal of x being the fraction of a gallon of paint to be applied to each board, one coat. Having the weight of the paint per gallon, we easily get the amount of paint by weight to apply to each board, one coat on all sides. When this second coat of paint is thoroughly dry a similar coat is applied, and when dry the boards can be compared for the covering power of the paints on them. We mention the painting of three boards with each paint to be compared; the purpose of this is that variations in results are obtained between boards which are apparently painted in an identical manner. These variations are not great, but it is thought best to eliminate them, to a certain extent, by painting three boards and selecting the one giving medium results for comparison with boards painted with other paints.

Perhaps the most important test that can be applied to paints is a durability test; that is, a test as to the permanency of the paint film itself. Boards painted, as in the making of the covering power tests described above, can be exposed to the weather and the durability of the paint films observed. Durability tests, to be of value, should be conducted with the same care as the covering power tests. The formulas on which the paints were mixed should be recorded, also the rate per gallon at which they were spread.

Mr. Arthur D. Little, chemical expert and engineer, 93 Broad Street, Boston, announces the reorganization of his coal department. Mr. Dwight T. Randall, M. E., has been made engineer in charge. Mr. Randall is well known through his work as expert in charge of the Fuel Tests, Technologic Branch, United States Geological Survey. Mr. Perry Barker, assistant chemical engineer, was formerly chemist with the Peabody Coal Co., Chicago; research chemist, Illinois State Engineering Experiment Station, and at various experimental plants of the United States Geological Survey, Fuel Testing Department. Messrs. Karl M. Way, Charles H. Jumper, Homer F. Braddock and Arthur D. Camp comprise the balance of the department.

The peat fuel commissioner, appointed by the Swedish government, in 1903, found that the English steam coal, used in Sweden, had 6,850 calories and machine peat 3,680, so the relation is 1.8:1. Practical tests showed the same result, viz., that one ton of coal is equal to 1.8 tons of peat and to 2.5 tons wood, so that one ton peat is equal to 1.33 tons of wood.

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

HENRY WYSOR, Metallurgical Editor.

PUBLISHED MONTHLY BY

THE CHEMICAL ENGINEER PUBLISHING COMPANY

355 Dearborn Street, Chicago

Entered as Second Class Matter, Aug. 19, 1907, at the Post Office at Chicago, Illinois, March 3, 1879.

Subscription—United States, Cuba and Mexico ————— \$2.00
Extra postage to Canada 25c a year; to foreign countries 50c a year.
Remittances may be made by check, draft, or money order in favor of
THE CHEMICAL ENGINEER PUBLISHING CO.

All matter connected with subscriptions or advertising should be sent to
THE CHEMICAL ENGINEER PUBLISHING CO., 355 Dearborn street, Chicago.
Anything intended for the Editorial Department should be sent directly
to the Editor, Richard K. Meade, Nazareth, Pa.

NOTES AND COMMENTS.

In our April, 1909, issue, page 113, we described a new calorimeter, known as the Emerson Fuel Calorimeter, which has recently been placed on the market. Through an oversight we neglected to give name of the manufacturer of this apparatus, and we take this opportunity to state that the Emerson Fuel Calorimeter is manufactured and handled by Eimer & Amend, 205 Third Ave., New York City. It may be of interest to know that over 50 of these outfits have been installed in the last six months, which is an almost unprecedented demand for a bomb calorimeter and certainly speaks well for the outfit.

Fuel Economy in the Metallurgical Industries.

If the progress of metallurgy has been stayed from the lack of any one commodity that commodity is efficient and available fuel. The heating agent will continue to be essential unless smelting processes are to be abandoned. The problems of obtaining and maintaining the fuel supply arose as soon as metallurgy had fairly reached the proportions of an industry, and though it has assumed a different form, the problem is still far from satisfactory solution. That the solution will ultimately be effected by substituting universally metal extraction processes requiring no fuel it is too soon to predict, though there is some ground for such conjecture, in view of already existing processes, some of long standing.

The agitation of the subject of the country's resources and their conservation has awakened the public mind to the fact of their exhaustibility, but it has not and will not teach economy in their usage. That, so far as is possible, will be accomplished by the principal users, as has been so far done in the past. Operators of processes using large quantities of fuel do not need legislation to drive them to economy; the inevitable law of profit and loss is incentive enough, and they have at their disposal the best possible teacher—experience. There is a popular notion that metallurgical processes are essentially wasteful of fuel. While it is true that in many of them but a small proportion of the heat energy is usefully applied, it is also true that remarkable improvements have been made to offset these losses. The fact should be borne in mind

that heat cannot be easily or cheaply retained, and that the difficulties of holding it increase in greater proportion with the high temperatures necessary in metallurgical processes. Fuel economies in metallurgy have been and are being worked out along three main lines, viz., manufacture, combustion and elimination.

H. W.

Manufacture of Fuels.

Coke and producer gas sufficiently represent the manufactured fuels of metallurgy. The first attempt to make coke, in imitation of the process of charcoal burning in heaps, served only to teach the practicability of converting coal into a more useful fuel for blast furnace work. The development of coking apparatus from the crude prototype of the common beehive oven to the modern retort represents not only the growth of a great industry, but also a remarkable scientific progress. The high cost of the by-product oven and the fact that superior coke has been made in the beehive oven are largely responsible for the present existence of the latter. That the objections to the by-product ovens have not prevailed is shown by their predominance in Continental Europe and their increase in this country. In view, however, of the present conditions a process for recovering all or a part of the waste heat and gases from beehive ovens is certainly desirable. This has long been practiced in a perfunctory way, the actual saving being but a fraction of the waste. Mr. Campbell's suggestions, published in this issue of THE CHEMICAL ENGINEER, while not backed by engineers, are worthy of further investigation.

Large and important as the coke industry is, it has a rival in the gas industry. The name of William Siemens would have been immortal had the genius of this great inventor brought forth nothing more than the gas producer. At first glance it might appear that gas producers do not accomplish a saving in fuel, since the actual conversion is attended by a loss of some 10 per cent of the heating power. The saving depends upon the high economy with which gas can be burned, the calorific effect being directed to the point desired instead of being so largely spent outside the laboratory of the furnace, as is done in furnaces which burn coal in separate fire places.

H. W.

Methods of Combustion.

Under this head are to be found the principal improvements, so far introduced, that have made for economy in the consumption of fuel. The main lines that have been followed may be summed up as follows:

1. The substitution of gas for solid fuel, and also the use of solid fuel in the pulverulent form with the practical economy above noted.
2. The introduction of mechanical feeds and such alterations in the construction of furnaces as avoids excess of either fuel or air, thus insuring complete combustion and avoiding undue chimney losses.
3. The introduction of regenerative firing, a system

by which, broadly speaking, unavoidable waste of fuel energy is recovered and utilized.

4. Purification of the air supply. The results so far gained by removing the moisture from the blast in iron smelting are encouraging at least, fuel economy having resulted with every trial. There is some hope for a system that will employ undiluted oxygen as the supporter of combustion. If the separation of oxygen from the air on the industrial scale is ever to be accomplished the economical result is evident enough.

5. The utilization of some inherent, heat producing substance to the replacement of all or a part of extraneous fuel. Here we are reminded of the Bessemer processes for refining metals, and of pyritic roasting and smelting.

These economies have been brought about not by legislation or public sentiment, but they are the fruit of the labors of scientists and practitioners, each abetted by his own reward. The technical skill and knowledge in the possession of metallurgical engineers, aided by instruments of precision, together with their vigilance, is accomplishing all that could be expected in the way of using fuel energy economically, and far more than was expected half a century ago. H. W.

CHEMICAL SOCIETIES

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—Samuel P. Sadtler, Pres.; John C. Olson, Sec'y, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN CHEMICAL SOCIETY.—W. R. Whitney, Pres.; Charles L. Parsons, Sec'y, Durham, N. H.

SOCIETY OF CHEMICAL INDUSTRY, NEW YORK SECTION.—Maximilian Toch, Pres.; H. Schweitzer, Sec'y, 128 Duane St., N. Y. City. NEW ENGLAND SECTION.—F. E. Atteaux, Pres.; W. H. Walker, Sec'y, Box 1189, Boston, Mass.

WESTERN ASSOCIATION OF TECHNICAL CHEMISTS AND METALLURGISTS.—W. D. Engle, Pres.; H. C. Parmalee, Sec'y, P. O. Box 1421, Denver, Colo.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Charles B. Dudley, Pres.; Edgar Marburg, Sec'y, Univ. of Penn'a, Philadelphia, Pa.

AMERICAN ELECTROCHEMICAL SOCIETY.—E. G. Acheson, Pres.; J. W. Richards, Sec'y, Bethlehem, Pa.

AMERICAN LEATHER CHEMISTS' ASSOCIATION.—H. T. Wilson, Pres.; H. C. Reed, Sec'y, Stamford, Conn.

The twelfth annual meeting of the American Society for Testing Materials will be held at the Hotel Traymore, Atlantic City, N. J., during the week of June 29 to July 3, 1909.

Owing to the fact that many members of the Society are interested in papers read before all the sessions, the program for the coming meeting will be arranged with a view of avoiding parallel sessions. An attempt will also be made to find time for an informal smoker and dinner.

The meetings of the American Society for Testing Materials have always been largely attended. Atlantic City, at this time of the year, is at its best, and probably no society can offer quite such a combination

of pleasant surroundings and interesting papers as can the American Society for Testing Materials.

AMERICAN ELECTROCHEMICAL SOCIETY.

The 15th general meeting of the American Electrochemical Society was held at Niagara Falls, Canada, May 6, 7 and 8, 1909. This is the third time that this Society has held its annual meeting at the great center of the American electrochemical industry. The headquarters during the meeting were at the Clifton Hotel, on the Canadian side, and all sessions were held in the convention room of this hotel. The total number of guests and members registered was 316 and 36 papers were scheduled to be read. The principal feature of the meeting, both in point of interest and drawing power, was the symposium of the electro-metallurgy of iron and steel. This was held Thursday morning, May 6, at 9 o'clock, and among those who spoke or read papers on this subject were the following: Robert Turnbull, Paul Girod, Dr. A. Kjellin, Ernesto Stassano, Remo Catani, Ch. A. Keller, Gustav Gin, Henry D. Hibbard, F. A. J. Fitzgerald, P. McC. Bennie and Jos. W. Richards.

At the Thursday night session, the retiring president, Mr. E. G. Acheson, delivered his address on the "Electro-Chemist and the Conservation of Our Natural Resources."

SUMMER MEETING OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.

The first semi-annual meeting of The American Institute of Chemical Engineers will be held at the Polytechnic Institute, Brooklyn, N. Y., on Thursday, Friday and Saturday, June 24 to 26, 1909. The following program has been arranged:

SCIENTIFIC PAPERS.

Thursday, June 24, 9:30 a. m., Address of Welcome to the City of New York, Comptroller Herman A. Metz; to the Institute, Prof. Irving W. Fay; 10 a. m., "Limits of Efficiency of the Power Gas Producer." Prof. W. D. Ennis; "The Utilization of Low Grade Fuels in the United States," O. K. Zwingenberger; "Creosote Oil from Water Gas Tar," President S. P. Sadtler; 12 a. m., business; 12:45 p. m., lunch at St. George Hotel; 2 p. m., "Some Experiments on Case Hardening of Steel with Gases," J. C. Olsen; "Automatic Acid Egg," Richard K. Meade; "The Centering of Great Industries in the New York Metropolitan District," Chas. F. McKenna; "Methods of Clay Control," J. G. Dean; 7 p. m., Subscription Dinner at Brighton Beach Hotel, \$2.00.

EXCURSIONS.

Friday, 9:30 a. m., excursion to the Atlantic White Lead and Linseed Oil Works, foot of Gold street, Brooklyn, N. Y. (The manufacture of white lead, linseed oil, lead pipe and sheet lead.) 11:30 a. m. through the courtesy of the National Lead Company, their steam lighter "Atlantic" will convey the members of the Institute and their guests up the Hudson River. 1 p. m., excursion through the Edgewater plant of

the Corn Products Refining Company. (The manufacture of glucose, starch and corn by-products.) 3:30 p. m., excursion through the Edgewater plant of the Warner Sugar Refining Company. 5:30 p. m., return trip on the steam lighter "Atlantic."

Saturday, 9:30 a. m., excursion to the Standard Oil Company's plant at Bay Way, N. J. (The refining of petroleum and by-products.) Through the courtesy of the Standard Oil Co., the members of the Institute and their guests will be conveyed by a steamboat to Bay Way, N. J. The boat will leave Pier 4, North River, at 9:30 a. m. The plant of the Consolidated Gas Co. at Astoria, L. I., may be visited during the afternoon, the trip being made via the new Blackwell's Island Bridge.

Hotel headquarters will be at the Hotel St. George, 51 Clark street, Brooklyn, N. Y. *All chemists* who desire to do so, are cordially invited not only to be present at the sessions Thursday, at which the scientific papers will be read, but also to attend the excursions. It is, however, understood that chemical engineers who are allied with competing companies, will not attend these excursions unless they declare themselves and can extend the same courtesy of inspection of their own plants.

The annual meeting of the American Foundrymen's Association was held in Cincinnati, May 18, 19 and 20th, 1909, in connection with the American Brass Founders' Association. The sessions of the two Associations were held jointly so that members of the one body, who might be interested in the deliberations of the other, could attend both; the one exception being the final session of the Associations, at which officers were elected, etc.

At the session Tuesday afternoon, May 18, speeches of welcome were made and also the presidential addresses of Mr. L. L. Anthes, of the American Foundrymen's Association, and Mr. W. R. Webster, of the American Brass Founders' Association. The reports of the secretaries and treasurers of the two associations, of the committee on standard specification for Foundry Pig Iron and of the committee on Prevention of Accidents in Foundries were also presented at this meeting.

In the evening a reception was tendered the visiting foundrymen and their ladies by the members of the association in Cincinnati.

Wednesday morning and afternoon were devoted to the reading of papers, while Thursday afternoon and evening were given over to a ride on the Ohio river and a barbecue.

A splendid exhibit of apparatus and machinery by the Foundry and Manufacturers' Association was also in operation during the week, and was visited by most of the foundrymen in attendance. Detroit, Mich., was selected for the place of meeting in 1910 and the following officers were elected for the coming year: Of the American Foundrymen's Association, A. P. Waterfall, Detroit, president, and R. Woldenke, Watchung,

N. J., secretary; of the American Brass Founders' Association, W. R. Webster, Bridgeport, Conn., president, and W. M. Corse, Detroit, secretary.

Among the papers likely to be of interest to chemical engineers, may be mentioned the following: "The Manufacture of Brass Ingot; Its Uses and Advantages," by W. M. Corse; "The Use of Waste Heat," by F. W. Reidenbach; "The Cost of Steel Melting in Foundries," by Bradley Stoughton; "The Side Blow Converter for Steel Castings and Its Operation," by J. S. Whitehouse; "Open Hearth Methods for Steel Castings," by W. M. Carr; "Notes on Air Furnace Construction for Malleable Castings," by W. H. Kane; "The Use of Pulverized Coal for Foundry Purposes," by Richard K. Meade; "The Practical Value of Chemical Standards for Iron Castings," by J. J. Porter; "Pyrometry in the Annealing Room," by S. H. Stupakoff; "General Principles of Operation of Industrial Pyrometers," by C. H. Wilson; "Notes on Brass Melting," by Chas. T. Bragg; "Melting of Brass Turnings in the Oil Furnace," by E. H. McVeen; "Electrolytic Assay of Copper," by Geo. L. Heath; "The Tensile Strength of Zinc-Aluminum Alloys," by W. D. Bancroft; "Modern Cupola Practice," by J. C. Knoeppel; "Notes on Steel Scrap in the Cupola," by C. R. McGahey.

BOOK REVIEWS.

LABORATORY EXPERIMENTS IN METALLURGY. By Albert Sauveur, Professor of Metallurgy and Metallurgy in Harvard University, and H. M. Boylston, Instructor in Mining and Metallurgy in Harvard University. 26 x 21. 73 pages. Cloth. Price, \$1.25. Published by the Authors, Cambridge, Mass. 1908.

As stated in the preface, the authors' aim was primarily to serve the needs of Harvard students taking the courses in General Metallurgy and the Metallurgy of Iron and Steel. It is expected, however, that other teachers and students, and practitioners as well, will find the book useful.

The book is divided into two parts, the first part dealing with general metallurgy and the second part with the metallurgy of iron and steel. The 13 experiments under general metallurgy include the coking and proximate analysis of coal, calorimetry, pyrometry, the melting points of metals and the reduction of metals by carbon, by oxide and sulphide mixtures and by the thermit reaction. In the second part there are 13 experiments in the heat and mechanical testing of iron and steel. Three of the experiments deal with the influence of carbon and one with nickel upon the steel. Many of the experiments are accompanied by drawings or diagrams, and 10 useful computation tables are given.

Metallurgy is perhaps the most composite of all the industrial sciences and the most difficult to teach comprehensively. The old method of teaching it en-

tirely by lecture and illustration is no longer adhered to by progressive teachers. On the other hand, the teacher finds well chosen experiments as useful to the student of metallurgy as laboratory work is to the student of chemistry or physics. The greater the number of experiments, provided each elucidates some principle, the more thorough and practical is the course. To those favored few among teachers of metallurgy who have well equipped laboratories at their disposal the more important question lies in the selection of the most useful experiments, not in the number of laboratory reports that should be required of the student. In the treatise under consideration the experiments are admirably chosen. The care with which they have been prepared, the system with which they are arranged and the clearness of the text should appeal to both teachers and students. The main criticism lies in the incompleteness of the part dealing with general metallurgy. Some difficulty will be experienced in obtaining good results by the method of Experiment 20, p. 56. High carbon steel bars will be checked by quenching from a temperature of 850° C., and the results of subsequent mechanical tests vitiated. For its scope this little book probably has no equal. The authors deserve the co-operation of all interested in their endeavor to enlarge and perfect their work.

THE COPPER HANDBOOK. A Manual of the Copper Industry of the World. Vol. VIII. By Horace J. Stevens. 8vo. 1,500 pages. Cloth. Price, \$5.00. Published by the Author, Houghton, Mich.

Chapter I gives 20 pages on the history of copper. Chapter II devotes 20 pages to the geology of copper deposits. Chapter III deals with copper ores and minerals and their chemical composition, upwards of 300 minerals being described. The next eight chapters, covering 97 pages, deal with the mining, metallurgy and uses of copper, following which, in the next chapter is an exhaustive list of mining terms and their meanings. Chapters XIV—XXIV, occupying more than four-fifths of the entire volume, give a directory of copper companies and properties in all parts of the world. It contains 6,767 titles. The last chapter is devoted to the statistics of the copper industry.

This standard work has reached its most comprehensive and perfect form with the present issue. The aim of the author is fully accomplished in representing the copper industry up to date. The commercial status of the industry is given in a systematic and convenient form, no attempt being made to include a scientific treatise or to burden the text with technical details. The wide circulation alone speaks sufficiently for the merits of the book as a mining manual.

During the first five years of the United States patent office, the average number of patents issued per year was below 20, while during the last five years it has averaged 30,000 annually.

TRADE LITERATURE.

Footo Mineral Co., Philadelphia, Pa. "Complete Mineral Catalog." This is the 12th edition of this manual, which has been entirely revised and enlarged. Aside from the main purpose it serves as a catalog, it is a most useful handbook for any interested in mineralogy. The size is 24 x 18, containing 320 pages, with 300 figures and plates. It is bound in semi-flexible cloth, price \$0.50, or leather, price \$1.50.

United Engineering and Foundry Co., Pittsburgh, Pa. "Rolling Mill Machinery." A handsome catalog, bound in cloth and illustrated in half-tone. In the main it is an exhibit of the company's products in the way of rolling mills and allied machinery. The book contains 397 pages, size 22 x 26.

New York Engineering Co., New York. "The Empire Hand Prospecting Drill." 21 pages. Illustrated.

Allis Chalmers Co., Milwaukee, Wis. "Concentration of Lead, Zinc, Copper, Tin and Iron Ores." 48 pages. Illustrated.

A CHEMICAL CALENDAR.

The following review of a calendar issued by Eimer & Amend, of New York City, appeared in our April issue:

We have received from Messrs. Eimer and Amend, dealers in laboratory supplies, 18th street and Third avenue, New York City, a neat calendar containing a novel table of the International Atomic Weights. This table gives the values with both oxygen equal to sixteen and hydrogen equal to one. The figures have the values of those of the 1908 report. The novel feature of the calendar is the printing of the names, symbols and atomic weights of the various elements in different colors. All those elements belonging to the same group in Mendelejeff's table are printed in the same color ink, thus, the elements of group one in black, of group two in yellow, of group three in green, of group four in red, of group five in purple, while the ungrouped metals are printed in blue. This color scheme gives a very pleasing effect and also allows the chemist to see at a glance which elements belong to the respective groups. The calendar can no doubt be obtained by application to Messrs. Eimer and Amend.

So many inquiries were received for this calendar that the supply was soon used up, and in view of the many applications received after the supply was exhausted Eimer & Amend are now having a reprint made. If any of our readers applied for one of these calendars and failed to receive it, they should at once write to Eimer & Amend for one of the new issue.

In determining the calorific value of peat it is better to make direct determinations in a calorimeter than to rely on Dulong's formula, as determinations by his formula invariably give results 6 to 10% too low.

INDUSTRIES AND PLANT NEWS.

Asbestos. The United Indurated Fibre Co., now controlled by the H. W. Johns-Manville Co., asbestos manufacturers, will erect in the next 12 months an addition to its plant at East Lockport, N. Y., to cost about \$900,000.

Coke. The U. S. Steel Co. announces that the construction of coke ovens at the Gary, Ind., plant will be begun immediately. The first lot to be built will number 560 ft. and will use between 6,000 and 7,000 tons of coal per day.

Carbon Dioxide. The Liquid Carbonic Co., of Chicago, will begin construction, in the near future, upon a plant for the manufacture of liquid carbon dioxide, to cost about \$500,000. A plot of land comprising about 56 acres has been secured along the south branch of the Chicago River, at 33d St. and Kedzie Ave. The factory building will be a 6-story and basement, reinforced concrete building with a frontage of 1,000 ft. There will also be a number of smaller buildings.

Cyanamide. The American Cyanamide Co., which has a large plant at Niagara Falls, N. Y., will establish a factory in Baltimore, Md., for the manufacture of certain lime products. Cyanamide, as manufactured at the Niagara Falls, plant contains free lime, which is undesirable for use in mixed fertilizers. The Baltimore plant will be used to convert this free lime into sulphate of lime. The untreated or crude cyanamide in the future will be known as "lime nitrogen." This will be sent to Baltimore for treatment. The plant at Baltimore will cost between \$35,000 and \$40,000 and should be in operation by the first or middle of July.

Foundry. The Penna. Foundry Co., York, Pa., is having plans prepared for a new plant to be constructed of steel and brick to replace buildings recently destroyed by fire.

Glass. The North Judson Glass Co. recently incorporated, will build and equip a glass factory at North Judson, Ind.

Glue. The El Reno Packing and Producing Co., with a capital of \$500,000, proposes to build a plant two miles east of El Reno, to cost \$150,000. The new concern will engage in a general packing business, manufacturing by-products, such as glue and fertilizers. Work is to begin on the plant June 1st and it is to be completed by October 1st.

Iron. The Struthers Furnace Co., of Youngstown, Ohio, will build a modern blast furnace with skip hoist, pig machine and other equipments at that place, at a cost of nearly \$1,000,000. The new furnace will have a stack 83 ft. high with a 21-ft. bosh. The Anna stack of this company, which has been in use for years, is to be razed.

Nitrate of Soda. Consul Hanna advises that at a meeting held on March 29, 1909, it was definitely decided to discontinue the combination among the Chilean producers of nitrate of soda, for the control of the production and exportation of that article.

Fertilizers. Morris & Co., Chicago, have opened offices in the Empire Building, Atlanta, Ga., and will begin the construction of a fertilizer plant at Atlanta, to be known as the Morris Fertilizer Works. The new plant is scheduled to be in operation September 1st.

Oil. The International Oil Refinery Co. has been incorporated with a capital of \$11,000,000 to establish a refinery at Wilmington, Cal., to cost about \$100,000 and having a capacity for topping 10,000 barrels and refining 500 barrels daily.

Paper. A paper and pulp mill is to be erected at Kootenai, Idaho, by parties interested in the Marshall Field Co. of Chicago, Ill. The mill will cost \$1,000,000.

Paper. The Mountain Mill Paper Co., East Lee, Mass., are preparing to expend \$40,000 in improvements to their plant.

Plaster of Paris. The United States Gypsum Co. has purchased the plant of the Buena Vista Company at Plasterco, Va. This is a three-kettle mill with a capacity of 6,000 tons per month.

Portland Cement. At a meeting of the Directors of the Alpha Portland Cement Co., held in Easton, Pa., May 15th, Mr. A. F. Gerstell was elected president of the company, to succeed the late W. M. McKelvey, of Pittsburg.

Portland Cement. A 1,600-barrel Portland cement plant is being built at El Paso, Texas, by the Southwestern Portland Cement Co. The plant will be completed by October and the brand of cement will be known as "El Toro."

Portland Cement. The Acme Portland Cement Co. has contracted with the Fuller Engineering Co., of Allentown, Pa., for the construction of their new plant to be erected at Spokane, Washington. The plant will have a capacity of about 3,000 barrels per day.

Pulp. It is reported that W. R. Hearst, of New York, has purchased 1,000 square miles of pulp wood near Hermitage Bay, Newfoundland, and will invest \$10,000,000 in the production of pulp for paper. This plant will employ 3,000 men.

Pulp. The Ogdensburg Soda Pulp Co. will build a plant consisting of five factory buildings, boiler and engine house to cost \$750,000, near Ogdensburg, N. Y. The buildings will be of steel, brick and concrete.

Smelter. The British Canadian Smelter Co., whose plant at Chippawa was destroyed by fire in May, will rebuild at once on a larger scale.

Starch. Douglas & Co. of Cedar Rapids, Ia., will build a starch factory. The factory will be located at Crystal Ave. and 19th St., Kansas City, consist of three buildings and will cost about \$175,000.

Steel. Work upon the erection of an open hearth plant at the works of the Maryland Steel Co., at Sparrows Point, Md., will be started immediately.

Steel. The Youngstown Sheet & Tube Co. has let contracts for an additional sheet mill plant to cost \$500,000 at Youngstown, Ohio. This will increase the black sheet output of the company from 2,500 to 6,000 tons per month, and the galvanized sheet output from 2,000 to 4,000. The plant will consist of eight hot mills, four cold mills, a galvanizing plant and a warehouse.

Tin Plate. The McKeesport Tin Plate Co. will double its capacity by erecting a new plant adjoining the old one, at Portvue, Pa.

Wood Preserving. The American Creosoting Works, New Orleans, La., has purchased 35 acres of ground in East Shreveport and will erect upon this a creosoting plant having a capacity of 10,000 crossties per day. It is anticipated that the plant will be ready for operation in 60 days and will employ from 30 to 40 men.

RECENT INVENTIONS.

The following recent inventions have been specially reported for THE CHEMICAL ENGINEER by C. L. Parker, solicitor of patents and attorney in patent causes, 908 G street, N. W. Washington, D. C.

917,096. *Theobromine Double Salts.* Carl Mezger and Albert Weller, Frankfort-on-the-Main, Germany. April 6, 1909.

The process consists in causing theobromine sodium in solution and a halogen salt of an alkali to react on each other in molecular proportions.

917,129. *Manufacture of Hydraulic Cement*. Charles J. Potter, Willington Quay, England. April 6, 1909.

The cement is made by burning a mixture of calcareous matter, clay and silica, all almost free from iron, with fuel also almost free from iron, and then cooling the resulting clinker in a reducing atmosphere.

917,191. *Process for Obtaining Radio-Active Bodies from Uranium or Thorium*, etc. Adriaan P. H. Trivelli, Scheveningen, Netherlands. April 6, 1909.

The process consists in producing radio-active bodies from uranium, thorium or from their compounds, by exposing uranium, thorium or their compounds in vacuo to the action of the cathode-rays.

917,265. *Preserving Wood and the Like*. Bernard Diamand, Idaweiche, Oberschlesien, Germany. April 6, 1909.

The process consists of filling a vessel with the wood and impregnating fluid to displace the air therein, partially withdrawing the fluid while preventing the admission of air to produce a vacuum, and then reintroducing the fluid.

917,285. *Manufacture of Aluminum-Foil*. Alfred Gautschi, Gontenschwil, Switzerland. April 6, 1909.

The process consists in rolling as a packet, sheets of pure aluminum folded a number of times upon themselves the surfaces of the sheets in contact one with the other being always coated with a solution of oil and water, the rolling being effected between heated cylinders.

917,475. *Direct Process of Manufacturing Iron and Steel*. Thomas J. Heskett, Brunswick, and Montague Moore, Melbourne, Victoria, Australia. April 6, 1909.

The process consists in covering the reduced iron within a furnace with a slag which is so strongly mixed with a reducing substance that ferric combinations contained in such slag are reduced to ferrous combinations which cannot act on the reduced iron to oxidize it.

917,502. *Process of Making Phosphoric Acid and Glauber Salt*. Emerson H. Strickler, New York, N. Y.

The process of separating Glauber salt and phosphoric acid in the solution obtained by the digestion of phosphate rock in bisulphate of soda solution in combining proportions, by causing the Glauber salt to crystallize from the phosphoric acid by concentrating and cooling.

917,516. *Process of Making Prepared Sheets from Cores of Palm-Trees*. Victor von Alpengburg and Louise von Alpengburg, West Hoboken, N. J.

The process consists in subjecting the sheets obtained from the core of the palm-trees first to the action of a preservative solution containing tannic acid, then to a softening solution containing glycerine, then applying a size to the sheets, and lastly drying the same.

917,706. *Formic-Aldehyde-Containing Composition and Process of Making the Same*. Henry S. Blackmore, Mt. Vernon, N. Y. April 6, 1909.

The composition comprises maize oil and formic aldehyde.

917,707. *Process of Making Carbide or Carbide-Containing Electrodes*. Henry S. Blackmore, Mt. Vernon, N. Y. April 6, 1909.

The process consists in mixing an electro-conductive carbide with a solid hydrocarbon carbon-yielding compound and exposing the composition to the action of heat sufficient to dissociate the carbon-yielding substance.

917,758. *Calcium Salt of Dibrombenic Acid*. Emil Fischer, Berlin, Germany. April 13, 1909.

The salt is obtained by treating dibrombenic acid with chloride of calcium, which calcium salt is a white solid body, tasteless, odorless and almost insoluble in water, insoluble in alcohol but soluble in ether and chloroform and which is a valuable substitute for potassium bromide.

917,787. *Process of Making Storage-Battery Plates*. William Morrison, Chicago, Ill. April 13, 1909.

The process consists in mixing a suitable quantity of soft lead and an oxide of lead, and in then reducing the same

to paste form by adding a liquid preparation obtained by mixing together water and acetone, sulphate of ammonia and acetic acid.

917,828. *Process for the Manufacture of Soaps Containing Peroxides*. Richard F. Wolfenstein, Berlin, Germany.

The method consists in causing a peroxide salt of an alkali to act upon free fatty acid in the presence of heat.

918,025. *Process of Burning Cement Clinker*. Carleton Ellis, White Plains, N. Y. April 13, 1909.

The process consists in spreading the cement material over the upturning side of the kiln to a point within one of the upper quadrants of the kiln and projecting against and along the material so spread a flame jet which in cross-section is broad in one direction and thin in a direction at right angles, the broad side of the flame turned toward the cement material so spread out and the upper side edge of the flame intersecting the said material.

918,269. *Process of Producing Metals*. Henry S. Blackmore, Mt. Vernon, N. Y. April 13, 1909.

The process consists in exposing a substance, containing a metal and oxygen, capable of reacting with a carbide to yield metal, to electrolysis, while employing an anode containing calcium carbide.

918,381. *Metallurgy of Iron*. William S. Simpson and Howard Oviatt, London, England. April 13, 1909.

The process consists in producing iron directly from the ore by associating a carbo-hydrate with the ore in a fine state of division, and heating the charge to effect its reduction.

918,382. *Metallurgy of Steel*. William S. Simpson and Howard Oviatt, London, England, April 13, 1909.

The process consists in manufacturing steel directly from ore by reducing the ore by means of a carbo-hydrate and effecting carburization of the metal by means of another form of carbon at the same operation.

918,384. *Waterproof Cement*. Melville M. Smith, Fredonia, Kansas. April 13, 1909.

The invention consists in a process of making white waterproof cement, by the admixture of lime and clay as free as possible from iron, together with a flux, burning the resulting mass to the verge of fusion, that is to say, beyond the sintering limit, and grinding the resulting clinker with a mixture of clay free from iron.

918,397. *Process of Obtaining Goffering Effects on Yarns, Tissues, or the Like*. Carl T. Tredup, Godesburg, Germany. April 13, 1909.

The process consists in impregnating the goods first with a bath containing a coagulating substance, then calendering the impregnated goods with rollers having a temperature insufficient to cause coagulation, and then exposing them, in a suitable manner, to dry heat, sufficient to coagulate the impregnating matter and to form an insoluble coating.

918,419. *Process for Producing Carbides*. Remo Catani, Rome, Italy. April 13, 1909.

The process consists in coating carbon with a compound containing part of the element that is to form the carbide, and placing such coated carbon in an electric furnace and also placing in the furnace the element to form the carbide, the electrodes in the furnaces being coated with the same compound.

918,424. *Process of Purifying Smelter-Gases*. Paul Danckwardt, Denver Colo. April 13, 1909.

The process consists in eliminating the destructive ingredients from smelter gases, by passing the gases together with steam through a body of glowing carbon, and mixing the resulting gases with further quantities of the original gas-containing sulfur dioxide, after which the gases are brought in contact with a solution containing some metallic salt which will not react with the gases, cooled, and again washed with a solution of an iron salt.

The Chemical Engineer

A Monthly Journal of Practical, Applied and Analytical Chemistry

VOLUME X

July—December, 1909

The Chemical Engineer Publishing Co.
355 Dearborn Street
CHICAGO, ILL.

INDEX

Volume X—July—December, 1909

Subject Index

- | | | | |
|--|-------------------------------|--|-----------------------|
| <i>Acid Egg</i> , An Automatic..... | 20 | <i>Coke</i> , The Determination of Volatile Combustible Matter in—and Anthracite..... | 95 |
| <i>Ammonia</i> , The Development of the—Industry in Gas Works During the last Fifty Years..... | 77 | <i>Coke</i> , Rapid Determination of Ash and Phosphorus in.. | 130 |
| <i>Anthracite</i> , The Determination of Volatile Combustible Matter in Coke and..... | 95 | <i>Coke Oven</i> , The Pyrometry of the Beehive..... | 62 |
| <i>Apparatus</i> , New Laboratory..... | 134 | <i>Contact Process</i> , On the Determination of the SO ₂ Losses in the Waste Gases of the..... | 21 |
| <i>Ash</i> , Rapid Determination of—and Phosphorus in Coke | 130 | <i>Copper</i> , Comments on Volhard's Volumetric Method for | 58 |
| <i>Automatic Analyses</i> , Analytical Control of Boiler Firing by Means of..... | 147 | <i>Creosote Oil</i> , —From Water Gas Tar..... | 73 |
| <i>Babbitt Metal</i> , Rapid Analysis of..... | 131 | <i>Crucible</i> , A Simplified Combustion..... | 201 |
| <i>Belt Conveyors</i> , Capacity of..... | 49 | <i>Cyanide</i> , Analysis of Commercial..... | 102 |
| <i>Bituminous Materials</i> , The Examination of—for Road Construction | 96 | <i>Duquesne Steel Works</i> , The Chemical Laboratory of the..... | 173 |
| <i>Boiler Firing</i> , Analytical Control of—by Means of Automatic Analyses..... | 147 | <i>Electrolytic Assays</i> , New Device for..... | 169 |
| <i>Book Reviews</i> | 35, 66, 104, 144, 176 and 213 | <i>Enamel</i> , The Chemistry of Opaque Glass and.... | 54, and 128 |
| <i>Butter</i> , A Modified Method for the Determination of Salt in..... | 165 | <i>Filtering Apparatus</i> , An Automatic..... | 94 |
| <i>Calculating Charts</i> | 9 | <i>Foundry Facings</i> , Standardizing..... | 63 |
| <i>Carburetted Water Gas</i> , Notes on the Manufacture of —by the Lowe Process..... | 113 | <i>Gas</i> , The Determination of Total Sulphur, in..... | 132 |
| <i>Case Hardening</i> , Some Experiments on the—of Steel by Gases..... | 60 | <i>Gas Producer</i> , The Westinghouse—and the Manufacture of Clean Gas From Bituminous Fuels..... | 193 |
| <i>Cast Iron Vessels</i> , The Concentration of Sulphuric Acid in..... | 14 | <i>Gas Works</i> , The Development of the Ammonia Industry in—During the Last Fifty Years..... | 77 |
| <i>Cement</i> , Method of Clay Control as Practiced by the Western Canada—and Coal Company, Ltd..... | 52 | <i>Gravimetric Factors</i> —and their Logarithms..... | 45 |
| <i>Chamber Regulator</i> , The..... | 56 | <i>Grinding</i> , Mechanical Preparation of Solids for Chemical Treatment..... | 84, 124 |
| <i>Chemical Laboratories</i> , Suggestions for the Construction of..... | 106 | <i>Illuminating Gas</i> , The Power of Plaster to Absorb Sulphur from..... | 51 |
| <i>Chemical Laboratory</i> , The—of the Duquesne Steel Works..... | 173 | <i>Index to Articles on Applied Chemistry</i> 39, 73, 109, 147 183, 218 | |
| <i>Chemical Societies</i> | 31, 177 | <i>Industrial Notes</i> | 36, 67, 104, 178, 214 |
| <i>Chemical Treatment</i> , Mechanical Preparations of Solids for—Grinding..... | 84, 124 | <i>Iron</i> , The Influence of Chemical Compounds on the Properties of..... | 98 |
| <i>Chile</i> , The Nitrate Deposits and Industry of..... | 1 | <i>Iron</i> , Casting—in Permanent Molds..... | 28 |
| <i>Clay</i> , Method of—Control as Practiced by the Western Canada Cement and Coal Company, Ltd..... | 52 | <i>Iron Castings</i> , The Practical Value of Chemical Standards for..... | 24 |

<i>Lead Chamber, Sulphuric Acid—Construction</i>	89	<i>Soap, The Analysis of</i>	203
<i>Limestones, The Determination of Titanium in Argillaceous—(Cement Rock)</i>	163	<i>Sounding Tubes, Coating</i>	50
<i>Liquid Illuminating Gas, The Manufacture of—in Switzerland</i>	122	<i>Spring Steel, The Heat Treatment of</i>	171
<i>Liquid Meter, A</i>	88	<i>Standard Solutions, A System of</i>	204
<i>Mixed Acid, Design of a Plant to Manufacture from 60 to 80 Tons of—per day</i>	16	<i>Steam Turbines, Testing Oil for</i>	45
<i>New York, The Centering of Great Industries in the—Metropolitan District</i>	40	<i>Steel, Some Experiments on the Case Hardening of—by Gases</i>	60
<i>Nitrate Deposits, The—and Industry in Chile</i>	1	<i>Steel Scrap, The Use of—in the Cupola</i>	26
<i>Nitric Acid</i>	160	<i>Stirrer, A Simple Mechanical</i>	199
<i>Notes and Comments</i>	29, 65, 103, 143, 175, 211	<i>Sulphur, The Power of Plaster to Absorb—from Illuminating Gas</i>	51
<i>Oil, Testing—for Steam Turbines</i>	45	<i>Sulphur, The Determination of Total—in Gas</i>	132
<i>Opaque Glass, The Chemistry of—and Enamel</i>	54, 128	<i>Sulphuric Acid, —Lead Chamber Construction</i>	89
<i>Permanent Molds, Casting Iron in</i>	28	<i>Sulphuric Acid, The Concentration of—in Cast Iron Vessels</i>	14
<i>Phosphorus, Rapid Determination of Ash and—in Coke</i>	130	<i>Sulphuric Acid, The Chamber Regulator</i>	56
<i>Portland Cement, The Ultimate Composition of—and its effect upon Physical Properties</i>	183	<i>Tantalum, —and its Industrial Applications</i>	207
<i>Potash Industry, The German</i>	152	<i>Titanium, The Determination of—in Argillaceous Limestones (Cement Rock)</i>	163
<i>Pyrometry, The—of the Beehive Coke Oven</i>	62	<i>Vacuum Evaporation</i>	156
<i>Recent Inventions</i>	37, 69, 106, 144, 179, 215	<i>Vanadium, Methods for the Determination of</i>	199
<i>Salt, The Technology of—Manufacture</i>	109	<i>Vanadium Steels—Their Classification and Heat Treatment</i>	135
<i>Salt, A Modified Method for the Determination of—in Butter</i>	165	<i>Volatile Combustible Matter, The Determination of—in Coke and Anthracite</i>	95
		<i>Wash Bottle, A Compressed Air</i>	23
		<i>Water Gas Tar, Creosote Oil from</i>	73
		<i>Water, —Softening or Purification and its Saving</i>	117

Author's Index

- Bacon, F. O. New Device for Electrolytic Assays.
- Barnhart, J. M. A Modified Method for the Determination of Salt in Butter.
- Boyer, J. W. The Determination of Titanium in Argillaceous Limestones (Cement rock).
- Campbell, J. R. The Pyrometry of the Beehive Coke Oven.
- Cederborg, G. D. Analytical Control of Boiler Firing by Means of Automatic Analyses.
- Couman, H. B. A Simple Mechanical Stirrer.
- Custer, E. A. Casting Iron in Permanent Molds.
- Dean, J. G. Method of Clay Control as Practiced by the Western Canada Cement and Coal Company, Ltd.
- Douzard, Edwin. A Compressed Air Wash Bottle.
- Dull, R. W. Capacity of Belt Conveyors.
- Enequist, Erik. The Chemistry of Opaque Glass and Enamel.
- Falding, Frederick J. Sulphuric Acid Lead Chamber Construction.
- Fitzgerald, W. P. An Automatic Filtering Apparatus.
- Forest, C. N. The Examination of Bituminous Materials for Road Construction.
- Frazier, Schuyler. Design of a Plant to Manufacture from 60 to 80 Tons of Mixed Acid per day.
- Frazier, Schuyler. Nitric Acid.
- Friedrich, H. The Concentration of Sulphuric Acid in Cast Iron Vessels.
- Frink, R. L. The Chemistry of Opaque Glass and Enamel.
- Frohman, H. F. Standardizing Foundry Facings.
- Fry, Lawford H. The Heat Treatment of Spring Steel.
- Gill, Augustus H. Suggestions for the Construction of Chemical Laboratories.
- Grimsley, G. P. The Technology of Salt Manufacture.
- Hawk, Lester C. Gravimetric Factors and Their Logarithms.
- Hilgenstock, R. W. The Development of the Ammonia Industry in Gas Works During the Last Fifty Years.
- Hjorns, A. H. The Influence of Chemical Compounds on the Properties of Iron.
- Job, Robert. Testing Oil for Steam Turbines.
- Lema, L. The Nitrate Deposits and Industry of Chile.
- Ljungh, H. On the Determination of the SO_2 Losses in the Waste Gases of the Contact Process.

- McGahey, C. R. The Use of Steel Scrap in the Cupola.
- McKenna, Chas. F. The Centering of Great Industries in the New York Metropolitan District.
- Meade, Richard K. An Automatic Acid Egg.
- Meade, Richard K. Ultimate Composition of Portland Cement and its Effect upon Physical Properties.
- Miller, M. Water Softening or Purification and its Saving.
- Monroe, Chas. E. Coating Sounding Tubes.
- Moorehouse, L. B. The Determination of Total Sulphur in Gas.
- Olsen, J. C. Some Experiments on the Case Hardening of Steel by Gases.
- Peterson, Hugo. The Chamber Regulator.
- Porter, John Jermain. The Practical Value of Chemical Standards for Iron Castings.
- Richardson, Clifford. The Examination of Bituminous Materials for Road Construction.
- Rose, Walter J. A System of Standard Solutions.
- Sadtler, P. B. Vacuum Evaporation.
- Sadtler, Samuel P. Creosote Oil from Water Gas Tar.
- Schoen, Carl F. Notes on the Manufacture of Carburetted Water Gas by the Lowe Process.
- Shimer, Porter W. A Simplified Combustion Crucible.
- Shimer, Porter W. The Determination of Volatile Combustible Matter in Coke and Anthracite.
- Siemens, Alexander. Tantalum and Its Industrial Applications.
- Smith, J. K. Vanadium Steels—Their Classification and Heat Treatment.
- Thackara, A. M. The German Potash Industry.
- Theodor, H. Comments on Volhard's Volumetric Method for Copper.
- Tornberg, Knut. Calculating Charts.
- Ullmann, H. M. The Determination of Titanium in Argillaceous Limestones (Cement Rock).
- Ullman, H. M. Rapid Determination of Ash and Phosphorus in Coke.
- Weiffenback, John S. Some Experiments on the Case Hardening of Steel by Gases.
- Wysor, Henry. The Chemical Laboratory of the Duquesne Steel Works.

The Chemical Engineer

PUBLISHED BY

The Chemical Engineer Publishing Co., 355 Dearborn St., Chicago

Vol. X.

JULY, 1909.

No. 1.

THE NITRATE DEPOSITS AND INDUSTRY OF CHILE.*

By L. LEMA.

The nitrate deposits in the northern part of Chile constitute the only available natural source of supply to meet the world's demand for nitrate of soda. Of the Chilean exports, which in 1907 amounted to over \$102,000,000,000, more than 86 per cent were represented by mineral products, and of these nitrate of soda figured as the most important. These deposits lie in the desert of Atacama, a tableland lying at an altitude of over 3,000 feet in the north to 6,000 ft. in the south above the sea level, and bounded by a low range of hills which rise abruptly from the shores of the Pacific on the west and by the Andes proper on the east. In length this desert resembles a long sea of reddish clay and sand broken only by the River Loa.

It very seldom rains here and no water is obtainable except at depths varying from 200 to 300 ft. The zone of impure nitrate of soda, or nitratine, called there "*caliche*," runs from north to south at a distance of from 50 to 70 miles from the sea. The nitrate is found in horizontal beds varying from 4 to 6 ft. in thickness, covered sometimes by a few inches of loose sand, lime and stones, locally known as "*chuca*," but mostly by a stratum of a kind of conglomerate cemented by sand, salt and lime, which varies in thickness from 5 to 25 ft. The bed of nitratine overlies the same alluvial soil which forms the plateau stretching from this region to the foothills of the Andes.

Of the many theories advanced to account for the origin of these nitrate deposits the more probable one is that they were formed by the combination of the alkaline earths, soda, potash, etc., brought in solution by waters running from the Andes, with nitrogen from the air. These waters must have formed in former times, when the climatic conditions of the country were different from those existing to-day, a vast lake in the plateau along the foothills. Organic matter of some nature must have existed on the western shores of this lake, which decaying, formed a compound with the alkaline earths, which compound had the property to extract and assimilate nitrogen from

the atmosphere, the result of this being the formation of nitrate salts with sodium and potassium as a base. This is shown by the fact that poor nitratine exposed for several years to atmospheric influences increases considerably its proportion of nitrate of soda. Instances can be cited of grounds which had once been opened up and abandoned because of low proportion of nitrate, that were subsequently found to have increased considerably in nitrate, after exposure to the



Fig. 1—Nitrate Fields.

atmosphere for several years, and capable of being worked with satisfactory results.

Nitratine looks something like dirty table salt, being usually grayish white, but sometimes lemon yellow or grayish purple due to the presence of hydroiodate of magnesia and iodides of potassium and sodium. It is bitter and has a cooling taste. It is very soluble, has a specific gravity of 2.29, and a hardness of 2. The chemical composition, when pure, is 36.5

*Slightly condensed from an article appearing in Mining Science, Sept. 17 and 24, and Oct. 1st.

per cent, of soda (Na_2O) and 63.5 per cent of nitrogen pentoxide N_2O_5 . The "caliche" or impure nitrate carries on an average 30 per cent of sodium nitrate, 20 per cent of sodium chloride, 15 per cent of sodium sulphate, and 30 per cent of insoluble matter, such as sand and pebbles. It also contains small amounts of iodine, chromium, potash, magnesia and lime. The iodine is extracted as a by-product, although only present in the proportion of 0.3 of a per cent.

As early as 1840 private individuals began looking for nitrate in Peru and Bolivia, to which countries part of the nitrate bed belonged prior to 1880. No law limiting the number of claims existed, and many persons staked a larger number of claims than they could really work. These large tracts of nitrate ground were many years after transferred to English capitalists and formed the basis for one of the various corporations to operate upon. Owing to the barrenness of the country, lack of transportation facilities, and scarcity of water, regions close to the ocean were preferred for working, irrespective of the quality of the raw material. The plants were also small and the work was done in a very primitive manner. The same process, namely, that of extracting the salts by leaching the raw material with hot water, which is employed to-day, was applied at that time with the notable difference that small tanks with a capacity of only two tons, heated by wood fire were used. The purified nitrate was then shipped to the coast on mules and donkeys. This condition of affairs lasted until 1870, when the railroad was constructed from the coast. Large boiling tanks heated by steam were then installed and machinery for crushing the *caliche*. These improvements gave the nitrate industry a great impetus. The exports of Chilean nitrate (in long tons) for 5-year periods are shown by the following table:

1840-1844	73,232
1845-1849	94,806
1850-1854	149,960
1855-1859	259,394
1860-1864	327,034
1865-1869	487,324
1870-1874	1,095,628
1875-1879	1,305,418
1880-1884	2,220,928
1885-1889	3,318,520
1890-1894	4,813,670
1895-1899	6,204,636
1900-1904	6,513,096
1905, 1906 and 1907	5,045,000

Total exported up to 1907, inclusive. . . . 31,908,646

In 1876 the Peruvian government passed a law prohibiting any further cessation of grounds to private individuals, and with a view to nationalizing the industry appropriated the holdings already granted, agreeing to pay the owners in government bonds according to the value of their properties. The scheme failed owing to the financial condition of the govern-

ment, and the grounds were restored to the original owners. As a result of the war between Peru and Bolivia, on one side, and Chile on the other, the nitrate deposits in the former two countries were occupied by Chile in 1879 and afterwards ceded to this republic as a war indemnity. Chile appropriated all the unclaimed grounds to the state, and at present owns 2,500,000 acres of ground supposed to contain nitrates, or about one-quarter of the total area of nitrate-bearing ground.

It would be a difficult task to estimate with any degree of accuracy the nitrate of soda contained in the deposits. A commission appointed by the Chilean government to investigate the state deposits, estimated the quantity contained therein to be 500,000,000 tons

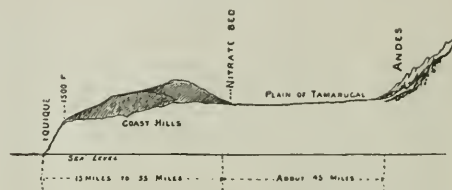


Fig. 2—General East and West Section of the Nitrate Fields.

of nitrate. This estimate, however, is conceded to be far too high, as private beds, covering three times the area of those of the government and which are known to have been worked out to the extent of at least 50 per cent of their nitrate contents, have produced from 1840 to 1907 only about 32,000,000 long tons. Improved methods, however, should allow of the extraction of about 40,000,000 tons from the private holdings, and about a like amount from the government properties, making the total amount of nitrate of soda now in the Chilean beds about 80,000,000 long tons.

Under the Chilean government the nitrate industry prospered rapidly. The use of nitrate of soda as a fertilizer was propagated in foreign countries and experimental laboratories on the application of nitrate of soda to plant food were established in Germany.

In the meantime the consumers realized the convenience of forming companies among themselves to restrict the production of nitrate to meet the world's demand and to keep up the prices. The *Combinacion Salitrera* or "Nitrate Combine" was first formed in 1834, for a period of one year. Under its provisions the nitrate producers pledged themselves to limit their output to the pro rata allotted them. So satisfactory were the results of this measure that the combine has been renewed ever since for longer periods, and with slight modifications of the original terms. Many nitrate owners who refused to join at first found out that such a condition was valuable to their interests also, as it prevented their grounds from being exhausted with undue rapidity, and joined the combine. Last March the whole of the nitrate owners, representing 139 "oficinas," with a total productive capacity of 3,678,000 long tons, signed the terms of the

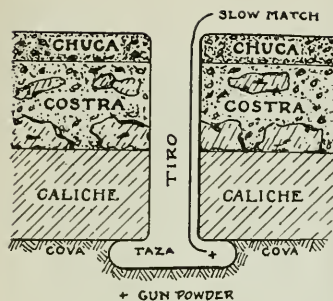


Fig. 3—Section of a "Tiro"
Ready for Blasting.



Fig. 4—Loading Nitrate at the Diggings.

new combination, which is operative to March 31, 1909. The pro rata allotted for the present economic year is about 47 per cent of the productive capacity, or a total of 1,791,783 long tons.

lic auction to concerns adjoining these grounds, and new concerns duly qualified to work them; its purpose being, apparently, to prolong the life of the existing plants rather than to increase the actual working capa-



Fig. 5—Crushing Machinery.

The Chilean government itself does not work for nitrate, but sells tracts of ground occasionally by pub-

city, which seems a wise attitude.

The probable value of the 139 nitrate plants or

"*oficinas*" existing today, could be placed at \$200,000,000 approximately. Considering that the yearly output represents \$80,000,000, about 50 per cent of which is net profit, and allowing that only three-

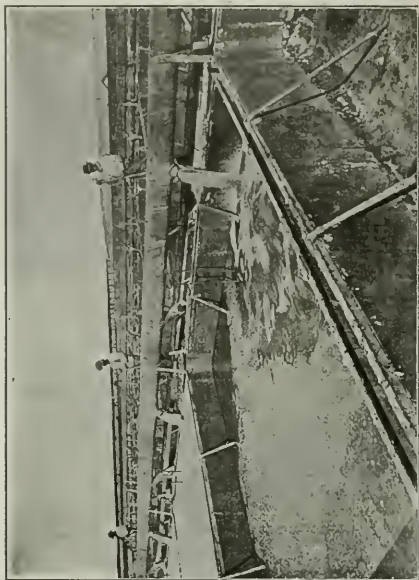


Fig. 6—Dissolving Nitrate from Crushed Caliche.

fourths of this net profit is distributed to the shareholders (at 15 per cent per annum on the stock), the balance of \$10,000,000 can be put in the sinking fund to pay back the capital, to be paid up, say in eight years. Of course, many of these companies have already reimbursed the capital paid up and can distribute the whole of their profits in dividends. The actual investment in the nitrate plants would probably reach \$80,000,000. English companies control about 60 per cent of the plants, Chilean concerns 15 per cent, German capitalists 15 per cent, and the remaining 10 per cent being controlled by Italians and other nationalities.

The average *oficina* has a capacity of about 400 long tons of the raw material a day, producing 100 tons of nitrate every 24 hours, or 30,000 tons in a year, of 300 working days. Some of them treat up to 2,000 tons of *caliche* per 24 hours. Each *oficina* stands, usually, in the middle of its territory, and consists of the plant for the refining of the impure nitrate mined, and the plant for the extraction of the iodine as a by-product, from the waters from which the nitrate has already been extracted. These stand near each other, with the administration houses on one side, and the offices, stores, stables and houses for the workmen on the other. Each *oficina* employs about 500 men, there being approximately 70,000 men employed in the nitrate fields. Most of these workmen are Chileans, as they stand the hard and dangerous work of the desert better than do the men of other nationalities.

They earn an equivalent of from \$0.68 to \$1.35. The management provides them with corrugated iron huts free of rent and with medical attendance at their expense. The management of some *oficinas* have difficulty in securing the number of hands needed for the normal work, owing to their distance from the towns, as well as to other causes, although strikes amongst workmen seldom occur, as the government deals with them in such emergencies with an iron hand.

Of the 500 men employed by the average *oficina*, 350 are miners working in the extraction of the raw material, 50 are used for the transportation of the raw material to the refining plant and 100 are employed in the work attending the process of refining at the plant. Almost all these men are paid on "piece-work" system.

The operation of the extraction of the *caliche* is commenced by sinking a small vertical shaft, or "*tiro*," usually 18 inches in diameter, to a depth varying from 10 feet to 30 feet, according to the thickness of the layers of "*chuca*," "*costra*" and *caliche*, as it must pass through these to reach the stratum of "*cova*," or loose alluvial sandy clay, underlying the *caliche*. This work is performed by hand by means of long 1 1/4-inch round iron bars, properly sharpened at one end.

As soon as the "*cova*" is reached, a small boy is sent down to dig out a cavity underneath the stratum of *caliche*, sufficiently large to hold from 500 to 2,000 pounds of black powder, according to the strata to be blown out. This powder is manufactured there for this purpose. This charge is so arranged that the

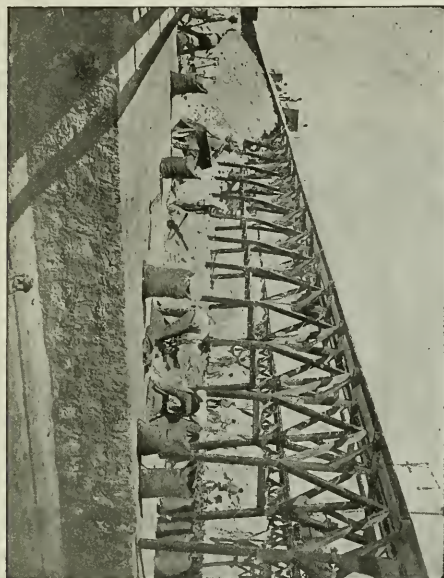


Fig. 7—Nitrate Pans.

gases of the combustion expand horizontally rather than vertically, and after conveniently placing two or three slow matches to ignite the powder from the surface, and then refilling the *tiro* with the same mate-

rial taken out from it, the charge of powder is exploded, throwing the layer of the *caliche* up to the surface in large pieces, for a radius of 20 feet from the point of explosion. To effect this first part of the

Fig. 8—Packing Nitrate into Bags.



operation of extraction, usually 50 men or drillers are employed in the *oficina*, who are paid by the running foot drilled.

Upon the blowing up of the layer of *caliche*, the second part of the operation of extraction commences, which consists of breaking up, by means of 12-pound sledge-hammers, and small cartridges of dynamite (2 ounces each), the large lumps of *caliche* and *costra*, mixed, and picking out those fragments of *caliche* which apparently carry more than 10% of nitrate of soda. The *caliche* is piled on one side, and the *costra* and the poor *caliche*, assaying below 10%, is made into walls around the pile of good stuff, leaving sufficient space for the carts to pass through.

Usually three or four miners take a section, where a *tiro* has been exploded, and work in partnership for eight or ten days, until all the available *caliche* is ready to be transported to the refining plant, they being paid by the piece. About 300 miners are employed in this work, delivering about 200 carloads a day.

The transportation of the raw material from the deposits to the refining plant of the *oficina* is usually made in two-wheeled iron carts, drawn by a team of four mules. The distance the raw material is to be transported varies from three to four miles, each cart making about five trips a day. If the distance is longer than this, narrow-gauge railroad lines are used, connecting the refining plant with several central depots for *caliche* in different parts of the grounds. The

cost of carriage of the raw nitrate to the refinery is by no means the least item in the cost of production, since the roads have frequently to be altered, needing constant repairs. Also, the maintenance of animals is high, forage being brought from the southern provinces, by sea. The forage used is dried alfalfa and barley, in the proportion of 25 pounds of the first to six pounds of the latter, for each mule per day. Fifty men are employed for the carriage and road repairing. Three hundred mules are sufficient for the 40 carts and the other requirements of the ordinary *oficina*, but each company generally keeps about 100 additional mules pasturing in the valleys near the Andes, to replace, periodically, the animals which are played out and in need of pasture.

On the arrival of the carts to the refining plant, the raw material is emptied on a platform slanting towards a row of Blake jaw-crushers, which reduce it to fragments about 3 in. to 4 in. in size. The crushers discharge the stuff, ready for leaching, into bottom dump cars, holding about 2 tons each, and running on tracks along the boiling tanks, by which means these are conveniently charged.

The boiling tanks, 8 to 10 in number, are arranged in two single rows, close together. They are rectangular in section, made of $\frac{5}{8}$ -in. iron sheets, and measuring, usually, 8x18x8 ft. deep. The 3-in. steam pipes, used for heating the liquid in the tanks, are arranged in a horizontal series of 12 pipes, one above the other, having a space of 3 in. between, and a 6-in. space be-

Fig. 9—Getting Ready a Nitrate Train.



tween them and the walls of the tank. The steam passes freely from one tank to the other and back to the boilers, after the last tank has been passed. The boilers, 4 to 6 in number, are all horizontal Galloway

flue boilers, measuring 6 ft. in diameter by 32 ft. long, and work at a pressure of from 70 lbs. to 80 lbs. They not only supply the steam for the boiling tanks, but also that necessary for the engines which drive the crushers, the dynamos for the electric lights, etc. They burn Welsh or Australian coal exclusively, of which over 500,000 tons a year is imported into the nitrate-producing provinces. The proportion of coal consumed to the amount of nitrate produced bears a ratio

that of leaching it in hot water, in the tanks already described. The length of time required to obtain the partial solution of those sales varies from 5 hrs. to 8 hrs., according to the character of the material treated. *Caliche* rich in chloride of sodium necessitates longer time to dissolve, as the combined salt is less soluble than nitrate. The miners classify the *caliche* into three groups, viz.:

(a) The "white solid," rich in sodium chloride,



Fig. 10—Machinery in the Oficina.

of 1 to 6, while probably 250,000 tons are also used by the railways, etc. This coal costs from \$6 to \$8 per long ton.

These boiling tanks or "*cachucas*" are so connected as to allow the passing of the weak solutions resulting from the washing of tailings in one, to the adjacent tank in which another charge of *caliche* is being leached.

At a point between the bottom and the false bottom of the tank starts a pipe to run off the filtrates to the settling tanks. After the operation is over, the tailings, carrying still about 7% of nitrate of soda, are emptied through a circular gate, at the center of the bottom of the tank, falling on cars underneath, and from there they are thrown into the dumps.

The process to which the *caliche* is subject to effect the dissolution of its nitrate and iodine salts, is simply

hard and difficult to dissolve, carrying usually 25% of nitrate of soda.

(b) The "white porous," less hard than class a, easily soluble, and carrying up to 40 % of nitrate of soda.

(c) The "brown," or "*chancacado*," whose solubility stands between classes a and b, rich in iodine, and carrying about 35% of nitrate of soda. The proportion of iodine contained in this class ranges from 1 to 3 units for every 1,000 units of its nitrate contents.

When treating only white solid *caliche*, the operation of leaching takes about 8 hrs. to finish, whereas, with the porous material, 6 hrs. are sufficient. The plants usually treat three classes combined, whenever it is possible, the operation lasting then about 7 hrs. from the time steam is turned on until the last portion

of the rich, dense solution is run off to the settling tanks. To wash the tailings, discharge them and charge the tank again, 7 additional hrs. are necessary.

After the boiling tank has been charged with the crushed *caliche* and weak solutions from the iodine house, to about seven-eighths of its depth, steam is turned on and the boiling begins. The mass must be kept boiling for about 4 hrs. before the water has acquired the proper density to be run off (90° Twaddle). This density is, however, generally allowed to reach 115° Twaddle before they commence running off the liquid, which is continued at intervals of 15 min. to 30 min. As the strong solution runs out to the settling tanks, a corresponding quantity of weaker solution—about 85° Twaddle—is replacing it from the

about 2 in. from the top with the solution, the crystallization of the nitrate in solution begins as soon as the temperature decreases. To assist the precipitation of the crystals, the liquid must be frequently stirred, during the first 24 hrs., by means of rackets, in order to break up and sink the crust of salts, which form at the surface. From 72 hrs. to 96 hrs. are sufficient to precipitate most of the nitrate contained in the solution. The precipitate will then form a layer about 15 in. deep in the bottom of the tank. After this, the weak solution remaining on the top of the layer—usually of a density of 70° Twaddle—is run off into the sump, from where it is pumped to the iodine house for further treatment. The nitrate in the tank is then shoveled to the yard below, where it

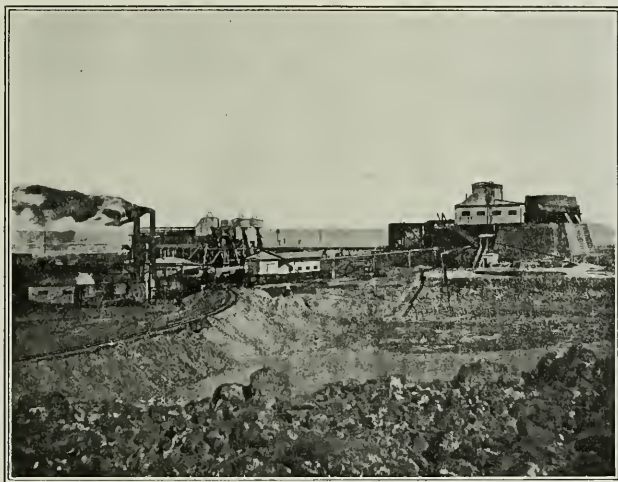


Fig. 11—A Nitrate and Iodine Plant.

adjacent tanks in which tailings of the previously leached charges are being washed with clear water.

When the solution does not contain much sodium chloride, it is run directly into the settling tanks. In treating stuff of the class "a," however, the liquid carries a considerable proportion of salt in solution, and it must be allowed to rest for 3 hrs. or 4 hrs. in deep tanks placed on an intermediate level, between the boiling and the settling tanks, where a quantity of horse dung is added to it in order to assist the sedimentation of the chlorides and sulphates of sodium present. After this, the purified solution is run into the settling tanks.

The "*batas*," or settling tanks, are 150 to 200 in number, rectangular in shape and measuring usually 20 ft. $\times$ 20 ft. $\times$ 20 in. in depth. They are made of $\frac{3}{8}$ -in. iron sheet, and arranged in rows, two abreast, forming and surrounding long rectangular *patios*, large enough to hold 2,000 or 3,000 tons of nitrate at a time, without obstructing the passage of the railroad trucks, on which the nitrate must subsequently be loaded. After the settling tanks have been filled to

must lie for 8 days, exposed to the rays of the sun, before it can be bagged and shipped to the port.

The bagging and loading is the final stage in the manufacture of nitrate. The bags are made of gunny-sacking, $1\frac{3}{4}$ lbs. apiece, holding 300 lbs. of nitrate each. The loading is performed by gangs of picked men, who handle these heavy bags and carry them on their shoulders from the yard into the railroad trucks. The capacity of these trucks is 200 bags each.

Most of the machinery used in these nitrate plants is of English manufacture, as also are the engines and rolling stock of the railways serving the nitrate-producing districts.

Of these railway lines, the most important is the Nitrate Railway Co., Ltd., taken over by Colonel North, once known in the business world as the "Nitrate King," in 1874, from the Peruvian concessionaries, Montero & Hos. This line has Iquique for its starting point and separates at the Central station, about 35 miles east of Iquique, into two branches running along the nitrate belt as far as Lagunas, in the south, and the port of Pisagua, in the north, with an

approximate total length of 240 miles. This line handles the bulk of the freight. The other lines serving the fields are the Agua Santa Ry. Co., the Junin Ry., Antofagasta & Oruro Ry., and Taltal Ry.

The nitrate shipping ports are, in order of importance, Iquique, Antofagasta, Caleta Buena, Junin, Tocopilla, Pisagua, Mejillones, Taltal and Coloso. None of these ports can be considered a good harbor, and the ships are obliged to anchor 3 or 4 miles distant from the shore. The bags of nitrate are usually loaded in launches, by means of cranes and taken to the ships in the offing in these launches. Before loading the bags in the launches, the weight of the nitrate is taken by custom-house officers, which weight serves the government in the collection of the export duties.

In 1880, when the Chilean government took over the nitrate provinces, the export duty was fixed at a

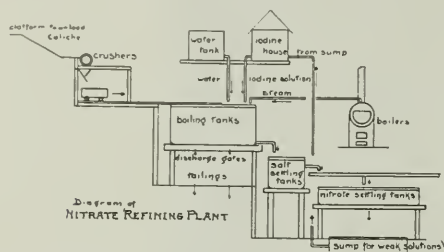


Fig. 12—Diagram of Nitrate Refining Plant.

comparatively low rate; it has been gradually increased, however, until today it stands at \$0.576 U. S. currency per quintal of 101.413 lbs. This duty on the exportation of nitrate is the principal item in the government's budget, representing about \$22,500,000 a year, out of total income of \$30,000,000. It has been calculated that the Chilean government has derived the total sum of \$280,000,000 from this tax, up to 1904.

On nitrate consumed in the nitrate plants for the manufacture of the black powder, used there as an explosive, no tax is collected by the government, although the producer has to pay the municipality, where his plant is located, the assessment tax due, according to Chilean municipal laws.

Strange as it may seem, no nitrate is consumed in Chile for fertilizing or other purposes, except that used for the manufacture of black powder by the *oficinas*, which amounts probably to 50,000 tons a year.

The sales of nitrate are made to well-known, old established firms dealing in nitrate at Valparaiso, through local brokers. In the sale contracts, one of the most important features is the clause relating to the percentage of salt allowed as a maximum in the nitrate. This maximum is usually fixed at 2%, and any fraction in excess of it renders the seller liable to the payment of a very heavy fine. Naturally, in the contract it is stated whether the nitrate sold is "ordinary" or "refined," i. e., carrying 95% or 96% of

sodium nitrate. On the delivery of every car of nitrate samples are taken from 8 or 10 bags, by both contracting parties, which samples are sent for assaying to different well-known chemists, the average of the two assays being accepted as basis of settlement.

The payments on the contracts are made through local banks, upon the full delivery of the amount contracted for, f. o. b. at the designated port. The unit taken for the nitrate quotations is the "cwt.," equal to 112 lbs.; the one used in paying the export duty is the quintal of 46 kilos, equal to 101.413 lbs.; and that used by the producer, in working out his cost of production, paying freight, etc., is the Spanish quintal of 100 lbs., all avoirdupois weight.

From the foregoing details, the general conditions of the producers of nitrate in Chile may be understood. To give an approximate idea of the profits, an estimate of the cost of production, free on board at the port of shipment, inclusive of the export duty, is given. The estimated cost is only approximate, and should be taken as representing the cost of production at the average "*oficina*," working under normal conditions.

APPROXIMATE COST OF PRODUCTION, AT THE AVERAGE "OFICINA," OF ONE SPANISH QUINTAL OF NITRATE OF SODA, F. O. B. AT ANY OF THE NITRATE SHIPPING PORTS OF CHILE, IN CHILEAN PESOS OF 8D. TO THE PESO.

	Pesos.
Extraction, including boring, explosives, and labor in sorting the caliche.....	.97
Carriage, including labor, maintenance of animals and wear and tear of teams and carts....	.45
Refining, including crushing and leaching (both labor and fuel), oils, lighting, repairs and wear and tear of machinery.....	1.72
Bagging and loading, including value of bags and labor	.25
General expenses, including management expenses, municipal taxes, etc.....	.85
Transportation, including railway freight, and storage in port.....	.65
Shipping expenses, lighterage, policy, commission, etc.	.25
Cost on board	5.14
Plus—	
Export duty, at 28d per 101.4 lbs.....	3.45
Total cost on board.....	8.59
Minus—	
Profit made in the extraction of the iodine, representing per quintal of nitrate.....	.45
Approximate cost on board.....	8.04

This cost per 100 lbs., in American currency, would be\$1.34
By drawing a comparison between the estimated

cost of production above shown, and the actual market price of nitrate of soda, which for the last few years could be placed at an average of \$2 per 100 lbs., a fairly accurate idea can be formed of the profits accruing to the nitrate operators. There are, naturally, plants which can produce more cheaply than the estimate given, and again some which could not produce at that rate, this being governed by the richness or relative impoverishment of the ground, labor conditions, distance to the port of shipment, etc. This last factor affects the cost sensibly, inasmuch as the freight charges over these railways are high, both for the nitrate shipped to the port, and for the coal necessary for refining it; however, the net profit for the average *oficina* can reasonably be rated at 49-54 per cent of the cost of production.

As has already been mentioned, iodine is manufactured in Chile only as a by-product of nitrate. The iodine salts are obtained in all kinds of *caliche*, but especially in the varieties known as *chanacodo* or *brown caliche*. The iodine salts are dissolved with the nitrate salts in the process of leaching, and are extracted from the solution, after the settling of the nitrate has taken place in the bateas. To effect this, the weak solutions of nitrate—density 70° —are pumped up from the sump, where they have collected, into the iodine house, near the nitrate refining plant, and there treated in long, rectangular, open tanks with dilute sulphuric acid, manufactured in the *oficina*, or imported from abroad. The hydro-iodates of potassium, etc., are decomposed by the acid, forming potassium sulphates, and setting iodine free. The length of time necessary to effect this reaction in each tank—each holding about 1,000 gallons of the solution—is about 2 hrs., during which time the liquid must be stirred constantly. The reaction having been accomplished, the liquid is allowed to rest for 24 hrs., in order to settle the iodine, potassium sulphates, etc., after which the clear solution is syphoned from the tank. The precipitate is taken out, washed repeatedly with fresh water, and pressed into cakes weighing 80 lbs. each. These cakes are stored in a dry place, until a quantity has been collected. The iodine is then extracted by sublimation. The sublimation of the iodine is effected in closed retorts, in charges of 300 lbs. to 400 lbs., the retorts being charged every 10 hrs. or 12 hrs. The operation of subliming 3,000 lbs. of iodine takes about 10 days. After the operation is over, and the crystals of iodine gathered in the clay pipes, forming the condensing chamber, have cooled completely, the product is taken out, filled into wooden, pitch-lined kegs, and shipped to England for sale.

The combination of Chilean iodine producers is operating under an agreement with Anthony Gibbs & Sons of London, by virtue of which the firm is to act as sole agent for the sale of iodine there, the shipments being sent to them on consignment. The monthly quantity sold by them is prorated amongst producers, according to the amount of stock they may have on hand in London at the time of settlement.

CALCULATING CHARTS.

By KNUT TORNERG.

Assistant Engineer in the Engineering Laboratory of General Electric Company, West Lynn, Mass.

Anybody who has had to perform a considerable amount of calculation of whatever kind, has doubtless at times felt the need of some quick and direct means to arrive from the premises to the final results. To be sure, a slide rule helps to relieve much of the strain of long and tedious, though perhaps, otherwise simple, arithmetical processes. But in many cases even the use of that instrument becomes onerous on account of the many intermediate figures which may have to be found in order to get at the ultimate answer. Not only is the frequent setting and reading of the slide rule in itself a labor tiring to the eyes, but, to secure reasonable accuracy, the mind also must be constantly on the alert to guard against progressive errors. Then, there is always the possibility of wrong annotation of the readings. As the number of manipulations increase, so do the opportunities for mistakes of one kind or another multiply. Whether this condition is aggravated when the calculations are performed in the old-fashioned way by pencil and paper, is a question by no means to be answered off-hand in the affirmative for all cases. The comparative accuracy of results obtained by the two different methods will depend, to a great extent, on the person doing the work, and also on the nature of the calculation.

By the use of suitable calculating charts the liability to accidental errors is very much lessened, if not entirely eliminated. The accuracy obtainable with calculating charts is altogether dependent on the scale in which they are drawn and on the care with which they have been made. Moreover, this degree of accuracy is always the same for the same chart. However, their special field of usefulness is not to obtain extreme precision, but rather to enable one to secure quickly results which are true within a reasonable predetermined degree of approximation. In addition, whatever the accuracy for which the chart is constructed, the results obtained are at least free from the suspicion which sometimes lingers in the mind of one who has completed a long and tortuous set of calculations, as to the possibility of some mistake, due to carelessness, in some intermediate step, and consequently as to the reliability of the end result. This is especially true for cases where the nature of the problem is such that the figures found do not of themselves readily suggest that there must have been a gross error committed somewhere.

The uses of calculating charts, thus may be summed up to be:

1. To give, without calculation, directly from the original data conditioning a particular question, a reliable answer sufficiently accurate to be used for preliminary purposes.
2. To check the final figures of long and more or less intricate calculations, whether performed with or

without the use of a slide rule. If the answer found by means of the chart gives figures of the same order, as those arrived at by the other methods of calculation, the latter may be considered as verified, even though there should be more disagreement between the results than would be permissible if the same problem were calculated twice, by slide rule, or otherwise. For this purpose the calculating chart need not be designed for any very great degree of accuracy.

3. Whenever the nature and the number of similar calculations warrant the construction of a chart capable of giving results as accurate as those obtainable by the use of a slide rule, then its use is beyond doubt to be recommended in preference to the latter, since besides giving equal refinement of results, the chart accomplishes these results without any strain, mental or otherwise, and by virtue of its nature, cannot very well give rise to any flagrant mistakes such as might find their way in calculations by slide rule or by pencil, if constant vigilance is not maintained throughout the whole operation. In the case of the calculating chart all the mental work required for a particular kind of calculations has been done once for all. By cutting out a lot of intermediate steps there is a proportionate amount of time and work saved. Thus what little attention is necessary for the proper use of the chart is of the shortest possible duration.

The writer has taken so much pains in emphasizing at the outset the advantages of calculating charts, as he has frequently met people who have been prejudiced against their use by the supposed complication. The writer has prepared for his own use and convenience some charts, which he would not for this reason venture to publish—at least not in the present article—even after the foregoing elaborate preamble. However, this impression of complication disappears as one becomes familiar with the use of the chart. To receive full benefit of the time saving feature of any calculating chart, it should be used sufficiently often to enable one to perform the necessary operations without any preliminary "puzzling." The best way is for each person to construct his own charts. Since the number of combinations for which calculating charts can be advantageously designed, is indefinitely large, it will probably be necessary to do so in a great many cases of special nature.

In the following there will be shown and described a few samples of calculating charts which are fairly simple in operation, and great time savers when once fully understood and practiced. Also, the two charts, Fig. 1 and Fig. 2, illustrate one example—and provide a remedy therefor—of a condition which probably more than any other is responsible for a vast amount of avoidable labor and waste of time in calculation in general. The writer refers to the numerous conversions from one system of units to another, which are too frequently necessary in problems of all kinds, and more especially to the senseless intermingling in the same problem of data expressed in

different systems of units. Even the best of authors may be guilty of such inconsistencies. One author of considerable note, even after having deplored in the introductory portion of his book, this very condition, and the misunderstandings to which it is liable to lead, proceeds to use rather promiscuously, in the course of his treatise, both metric and English units, of different kinds. In the following examples, given for the purpose of explaining the use of the calculating charts to which they refer, the writer has intentionally exaggerated such intermingling of units.

Referring to Fig. 1, this shows a calculating chart designed for the purpose of determining the relative cost of using electrical energy or fuel as heating agents. In some cases electricity might be the more economical, in others some kind of fuel, whether gas, oil or coal, might be indicated on account of high rates for electrical energy or low prices for fuel. Or the working temperature desired may be low, and the efficiency of heat transfer in the fuel pressure correspondingly high. Again, cases might arise in which on account of the relation between the different factors it will be found that the most economical results will be obtained by using fuel up to a certain temperature, continuing from that point upward by means of electric heating.

EXAMPLE I.

A certain furnace process requires the maintenance of a working temperature of 1300°C . As far as the process itself is concerned, it may be assumed in this case, that heating by electricity or fuel is equally good. It will be further assumed that there are available fuel furnaces of 15% total average thermal efficiency when operating at 1300°C ., whether fired by gas, oil or coal. Thus the problem is simplified to a question of the relative costs of electrical energy and of such fuels as are available.

Suppose that electrical energy is obtainable at the rate of \$35 per kilowatt-year. From that point on the scale marked "Dollar per kw. year" pass horizontally to intersection with curve marked "Electrical energy." From that point pass vertically upward to top of scale which gives a reading .625 cents, which is what it would cost to generate 1,000 kilogram-calories by means of electrical energy at \$35 per kw.-year, when utilized in an electric furnace giving 75% thermal efficiency. To compete with this, fuel of whatever kind must not cost more than .625 cents per 1,000 kg. cal. when burned in a furnace giving 15% mean thermal efficiency. Starting from this value on the horizontal scale marked "15%" efficiency, a vertical line will cross a number of curves, marked with different "Basic Prices," each point of intersection corresponding to a definite temperature, read on the vertical scale to the left. As in our case the working temperature was 1300°C ., this vertical line crosses at that temperature an imaginary curve, approximately half way between the two curves marked ".090c" and ".100c" respectively, thus indicating a

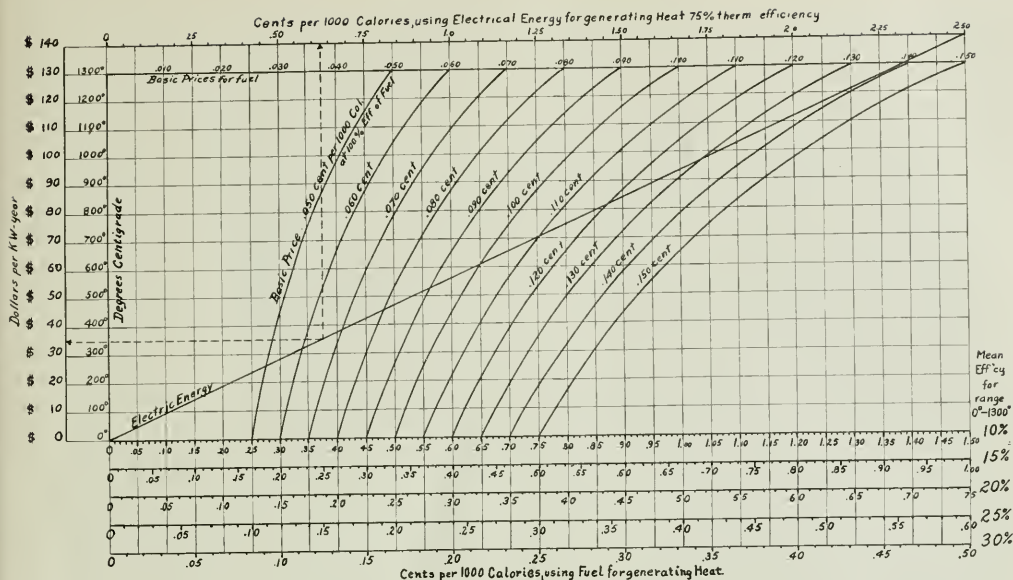


Fig. 1.

Comparison between the cost of generating 1000 Kilogram-Calories by electrical energy, utilized with 75% thermal efficiency, at different rates per kilowatt-year, and by the combustion of fuel, in furnaces of various mean thermal efficiencies (for total range 0°-1300°) at different "basic prices" (=theoretical cost of 1000 Kg. Cal. if the available heat value of fuel were utilized with 100% efficiency). For corresponding fuel, see lower chart.

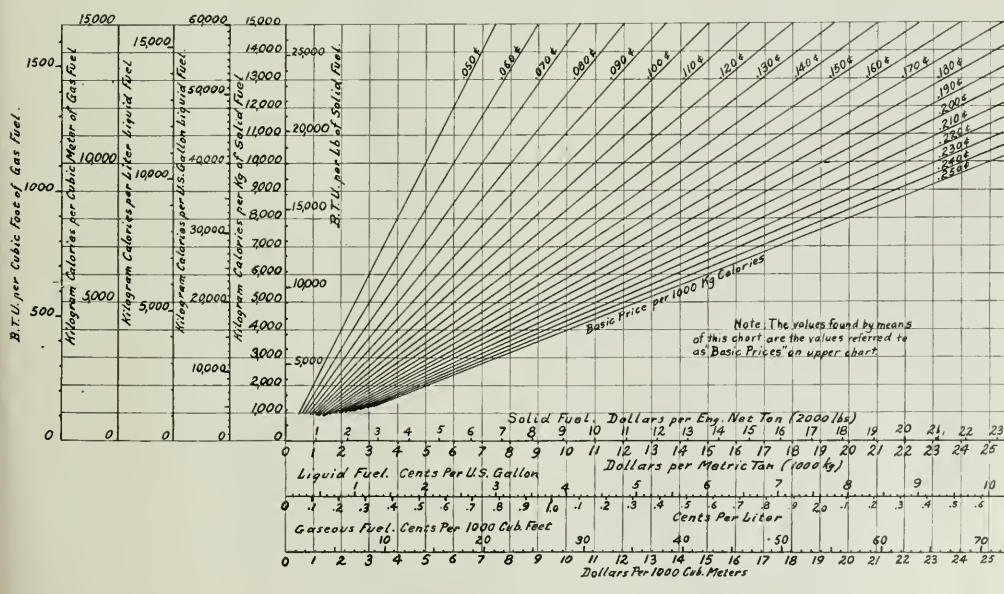


Fig. 2.

Cost of generating 1000 Kilogram-Calories by various solid, liquid or gaseous fuels of different net calorific values, if utilized with 100% thermal efficiency.

"basic price" of practically .094 cents for fuel of any kind which will be equal in economy to electricity at \$35 per kw.-year, under the conditions assumed. The term "basic price" is used here to designate the theoretical cost of 1,000 kg. cal. if all the calorific value in any fuel were converted into heat of 100% potential efficiency. To find the maximum price which we can afford to pay for any of the various available fuels, solid, liquid or gaseous, in order not to exceed this basic price, we turn to the lower chart.

This chart, Fig. 2, gives the cost of 1,000 kg. cal. if all the heat contents of a fuel is calculated as converted into heat. This figure is what has already been referred to as "Basic Price." As the heat value of any fuel may be given in several different ways, there have been provided a number of vertical scales containing the most common expressions. Similarly, the prices for fuels are given in a variety of ways on the horizontal scales. Continuing our Example 1, then, we choose a radial line marked with our basic price .094c. This will, in this case, be an imaginary line, about half way between the two radii marked ".090c" and ".100c" respectively. Let us assume that we can obtain a coal containing 7,000 kg. cal. per kg. of coal. From this point on the proper vertical scale pass horizontally to intersection with the imaginary radius; then drop vertically to horizontal scale for solid fuel. Thus we find that the coal in question must not cost over \$6 per English net ton, or about \$6.50 per metric ton. Similarly, one finds the maximum prices for any quality of liquid or gaseous fuels which, under the conditions assumed in our example, will be equivalent to electrical energy at \$35 per kw.-year, for generating the heat required.

EXAMPLE II.

Assuming again the same furnace process as in Example 1, but starting our calculations from the other end, i. e., with known prices for the various heating agents. Supposing, then, our original data to be as follows:

We can contract for a certain uniform quality of coal at the rate of \$8.40 per metric ton. The calorific value of this coal is not stated, but by taking a representative sample to a testing laboratory we are informed that it is 10,800 British thermal units per pound of coal. We are offered a certain grade of oil, guaranteed to give 6,400 kg. cal. per liter at a price of 3.6c per U. S. gallon. From the local gas works we can obtain gas with a guaranteed heat value of 11,000 kg.-cal. per cubic meter, at a price of .45 cents per 1,000 cubic feet. We have available furnaces suitable for each kind of fuel, but differing in efficiency. The coal fired furnace will give, let us assume, only 10%, the oil furnace 15% and the gas furnace 20% efficiency. We wish to know whether it would not be cheaper to use an electric furnace giving 75% efficiency. The electrical energy can be furnished us at the rate of \$41 per kilowatt-year. To find an answer, which takes account of all the above data, refer to

Calculating Chart, Fig. 2, \$8.40 per metric ton and 10,800 B. T. U. per pound gives a point which falls on a radius marked .140c, which thus is the basic price for that particular quality of coal. Similarly, oil at 3.6c per gallon, in connection with a calorific value of 6,400 kg. cal. per liter, gives a point which falls on a radial line marked .150c, being the basic price for oil. For the gas a basic price of .145c is found in a like manner. With these basic prices ascertained, we turn to the other chart, Fig. 1. We find, first, that electrical energy at \$41 per kw.-year gives a cost of .725c per 1,000 kg. cal. By reading this value on the 10% horizontal scale and passing vertically upward, it intersects the curve marked .140c at a point which on the temperature scale gives us 100° C. This is the same as to say that the use of coal is practically out of the question, being equal in cost to electrical heating only up to 100° C. Next we read .725c on the 15% scale. A line passing vertically upward from this point intersects the .150c curve at a little above 800° C. This informs us that up to that temperature we can use the oil furnace with an economy equal to that of the electric furnace. Finally, starting with the same figure, .725c, from the 20% scale, we find that a vertical line intersects an imaginary .145c curve, half way between the .140c and .150c curves actually shown, at just 1,300° C.

Thus we have found out that, under the conditions assumed, the price of coal is prohibitive, that the oil furnace can be used for preheating up to 800° C., and that the gas furnace is equal in economy to the electric furnace. Considering the peculiar advantages inherent in the latter, it probably in a great many cases would be given the preference, even when the other kinds of furnace show a somewhat greater possible calorific economy. It is also well known that the economy of electric heating is superior, especially at higher temperatures. In the case of heating by combustion, the efficiency of heat transfer from the flame, or the hot gases produced, to the body to be heated, decreases with the difference between their temperatures. This, also, is clearly indicated by the general tendency of the curves on Fig. 1.

The above two examples probably are sufficient to show the possibilities of these particular calculating charts. As has already been stated, to receive the full benefit of their use, one must be familiar with the few simple passes required, according to the nature of the original data furnished in each particular case.

Fig. 3 shows a calculating chart, which, while, in a way also a time saver, was primarily designed for checking purposes. By means of this chart there can be obtained, by direct readings, a number of qualitative relations existing between chemical compounds and integral parts thereof. For instance, knowing the atomic or molecular weights of two complementary parts of a compound this chart will give—

- (1) Molecular weight of compound.
- (2) Percentage of the two complementary parts of compound.

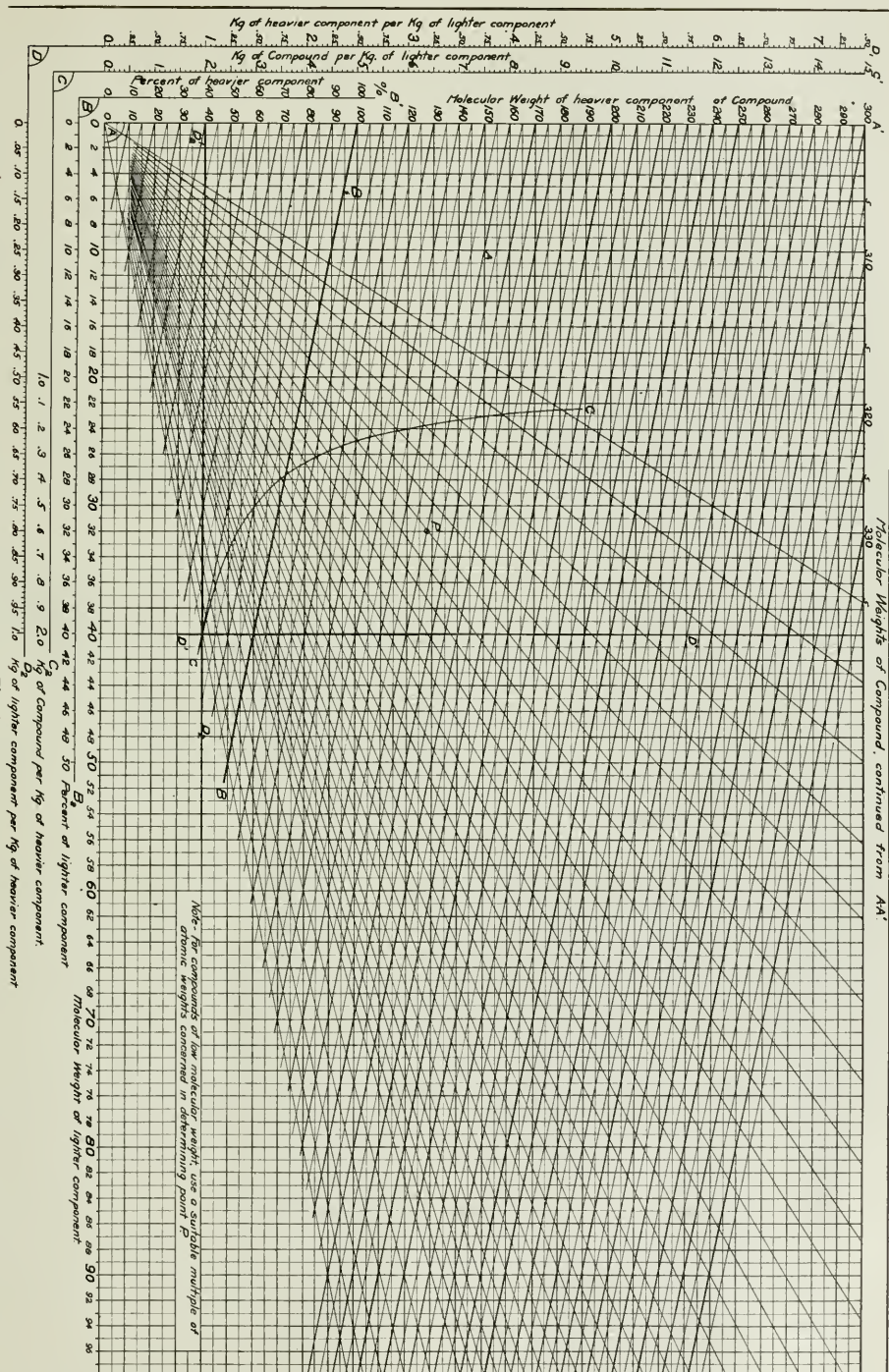


Fig. 3.

For finding, directly from atomic weights of complementary parts of a compound, the molecular weight; percentage; composition; weight of compound per unit weight of any part thereof; and amount of any particular element or molecular part, per unit weight of any other element or molecular part, contained therein.

(3) Weight of compound per kilogram of either complementary part thereof.

(4) Weight of one component part per kilogram of another. A simple concrete example will probably be the best way to explain the use of this chart.

EXAMPLE III.

Take for example the compound Cu_2S . One of the complementary parts of this is Cu_2 with a molecular weight, 128 (approximately). The other complementary part is one atom of S with atomic weight 32. Reading the heavier part, 128, on the vertical axis $A-A^1$, and the lighter, 32, on the horizontal axis $A-A^2$, the point P is determined. This point falls on one of the radial lines.

(1) By following, to the scale $A-A^1$, the oblique line (A) which passes through this point, the molecular weight 160 is found.

(2) By following the radial line to its intersection with the extra heavy oblique line (B) (parallel to those referred to for molecular weight of compound) and projecting this point of intersection on the scales $B-B^1$ and $B-B^2$, one reads on the former the percentage of the heavier part, $\text{Cu} = 80\%$, and on the latter that of the lighter part, $\text{S} = 20\%$.

(3) By following same radial line to its intersection with curve C and projecting the point of intersection on the scale $C-C^1$, one reads 5 kg. of Cu_2S per kg. of S (the lighter part), and, on the scale $C-C^2$, 1.25 kg. Cu_2S per kg. cu. (the heavier part).

(4) Again follow the radial line to its intersection with the auxiliary axes D^1-D^1 , and D^2-D^2 . By projecting the point of intersection with the first mentioned axis onto scale $D-D^1$, one reads 4 kg. of Cu (the heavier part) per kg. of S (the lighter part). Similarly, by projecting point of intersection with axis D^2-D^2 , one reads, on $D-D^2$, .25 kg. of S per kg. of Cu.

The use of this chart is not limited to simple binary compounds, however. By grouping or pairing the various component parts of any compound, in different ways, and regarding such a group as one of the complementary parts, any desired quantitative relations may be found. For instance, in the silicate $\text{FeO} \cdot \text{SiO}_2$ one may regard FeO and SiO_2 as the two complementary parts, or one may refer to Fe to SiO_2 in order to get the amount of iron corresponding to 1 kg. of SiO_2 ; or to SiO_2 in order to find the amount of silicate which corresponds to 1 kg. of iron. Many other combinations could be cited but the above will suffice to suggest the method of procedure in the case of polybenous compounds.

It will be noted that the chart, as here illustrated, is not universal in character. The present chart has been constructed especially for use in connection with a certain class of metallurgical calculations. In other words, provision has not been made for all known compounds. For instance, no compounds have been considered in which the proportion between the heavier part and the lighter part is greater than 8:1. When

the atomic weights used for determining the point "P" are very low (for example $\text{H} = 2$ and $\text{O} = 16$, in H_2O) a suitable multiple thereof may be used, as, for example, $\text{H} = 20$, $\text{O} = 160$, in order to bring this point P into the open portion of the chart.

By making this chart in a sufficiently large scale, one could insure that the point "P" always would fall on an actual radial line. But since this chart is not intended for very precise figures, one can, in cases where "P" falls between two radii, imagine such a line with a sufficient degree of accuracy in the resulting figures for checking purposes and rough estimates.

The writer has made another similar chart, for giving the heat of combination referred to the various component parts of a compound and to the compound as a whole. This chart, and some others of a more general nature, will be illustrated and described in a following installment.

THE CONCENTRATION OF SULPHURIC ACID IN CAST IRON VESSELS.*

By H. FRIEDRICH.

In nearly all articles on the manufacture of sulphuric acid, it will be found that the cost for the installment of the plant is not mentioned, whereas an exact account is given of the quality of the acid that can be obtained, the efficiency of the plant and the amount of fuel required. However the installment cost in comparison to the amount of fuel required, the duration and the efficiency of the plant, is of great importance, and to be taken in consideration where a choice of different methods is to be made.

A question which arises then is, What capital would a concentration plant require which would produce 10,000 kilograms of 66° Bé sulphuric acid (containing 93% H_2SO_4) and the duration of the plant? This is to say, that it is not the production in 24 hours, but the total production of the plant in say, 10 to 15 years, considering the necessary shutdowns for repairs and cleaning of the apparatus, which requires attention. Take, for example, the concentration in platinum, where the apparatus can be used only for pure acid and requires careful attention, but by which, of course, a perfect product is obtained. The first cost appears to be high but since the apparatus after 10 to 15 years' use is still in good condition, most of the invested capital is still on hand, or even has increased, as was the case a short time ago when platinum had increased in market value. In this respect, none of the new processes can compete with the concentration in platinum, whether the concentration is made in porcelain, glass, iron or "volvic." It is certain that the invested capital would be lost after the plant has been in operation for 10 to 15 years. It is safe to say that of all the concentration plants which were erected in the past few years there was not one which required less than 40,000 to 50,000 marks (\$10,000 to \$12,500) for apparatus and this amount will be comparatively speaking lost after 10 to 15 years.

*Translated from *Chemiker Zeitung*, xxxiii, 53.

Of course, it is not always possible to have all advantages in one process. While in one, a pure acid is obtained, difficulties are experienced in the working of the apparatus, while in the other, the conditions are reversed. It is, therefore, necessary to find the intermediate, and this again depends upon the purpose which the acid has to serve. A chemically pure acid cannot be obtained by any system, not even from platinum vessels, nor is it necessary, in most cases. Of course from an impure acid which is yielded by the chamber process, a 66° acid cannot be obtained by simply concentrating. It must be taken in consideration to what extent the impurities are harmless, and this varies in specific cases. The consumer, who is able to use a slightly brown-colored acid without disadvantage, should buy it at a cheaper price, as long as it is of full grade, instead of insisting on a colorless and water-clear product. It is very surprising that consumers usually insist on a water-clear product when buying 93% acid, while they accept any kind of 96, 97 and 98% acid and monohydrate made by the contact process.

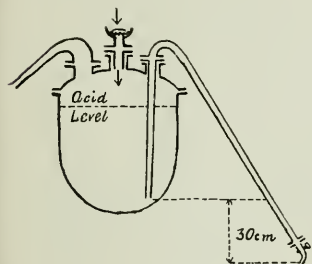


Fig. 1.

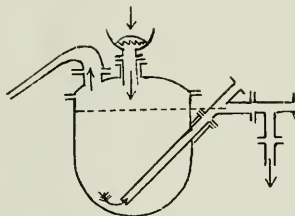


Fig. 2.

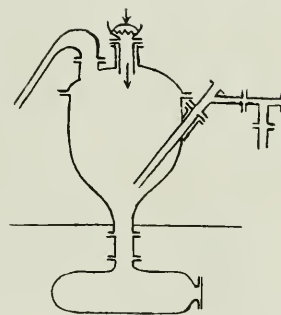


Fig. 3.

In connection with the above statement the author describes a concentration plant which, of course, is not entirely free from disadvantages, but requires only small capital for construction. Such a plant can be erected for \$2,500 to \$3,000 with a capacity of 10,000 kilograms of 93% acid. This figure cannot be outdone by any other installation.

In the '80s a factory near Dresden employed cast-iron vessels for the concentration of sulphuric acid by running constantly a comparatively small amount of 50 or 60° Glover or chamber acid on the surface of a large amount of boiling 66° acid. The finished product was discharged by means of a syphon which reached to the bottom of the concentrator. This process was supposed to have been invented by Adolf Tedesko, superintendent of the plant. About 1900 the Clayton Aniline Co. obtained a patent for a similar process. The patent does not differ from Tedesko's process in method but simply in construction of the apparatus. Figure 1 gives an idea of Tedesko's apparatus.

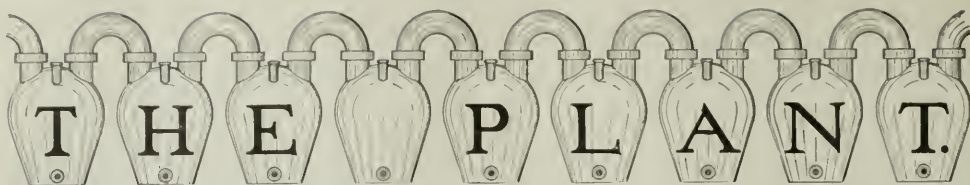
The vessel had a capacity of 5,000 kilograms of 66° Bé acid and produced the same quantity of 93%

acid in 24 hours. The total space required for this plant did not exceed 15 to 20 sq. yds. The entire cost for construction amounted to about \$750 to \$1,000. A concentrator would last about one year on an average, and in some cases a vessel would even stand two years' wear.

Of course, the acid produced by this process was not of special purity, but the acidity was always of 93% and often 94 to 94.5%. The limit of the efficiency is not due to the short wear the vessel gives, but to the difficulty in condensing the distillate, except when platinum condensers are used. This acid is comparatively free from iron as the solubility of iron decreases with the concentration of the acid. The large amount of iron usually found in 96 and 98% acid and monohydrate made by the contact process, is not dissolved in the acid but suspended as very fine mud.

A few years later the author installed several concentrators in a factory in South Germany, with which he was connected. An attempt was made to improve the apparatus, in order to obtain a continual process by substituting the syphon, used in Tedesko's appara-

tus, by an overflow, as shown in Fig. 2 given above. However, on account of the slight difference in the solution level, the mud remained in the vessel and increased to such an extent that after four weeks the apparatus had to be shut down in order to remove the sediment. To overcome this difficulty the author constructed an improved apparatus whereby the sediment is collected in a small vessel of about 3 cu. ft. capacity situated below the concentrator as shown in Fig. 3. Such an apparatus can be used at least six months before cleaning will become necessary. A full grade and water-clear acid can be obtained, as all the sediment settles in the lower vessel and a high efficiency of the fuel is obtained. The waste heat can be utilized for pre-heating acid in lead pans or the whole plant can be placed near the Glover so that the hot Glover acid can be run directly in the vessel without loss of heat. Thus an increased production is attained. This method of concentrating sulphuric acid cannot be surpassed by any other process, considering that in a working space of 15 to 20 sq. yds. about 5,000 kilograms of 66° Bé acid are yielded daily and that an investment of only \$1,000 to \$1,250 is required.



DESIGN OF A PLANT TO MANUFACTURE FROM 60 TO 80 TONS OF MIXED ACID PER DAY.

By SCHUYLER FRAZIER,

Consulting Chemical Engineer, Bristol, Tenn.

Mixed acid for the preparation of nitro-glycerine, etc., consists of nitric and sulphuric acids of high strength, combined in various proportions and of different degrees of purity according to formulæ and specifications of different manufacturers. This article describes one form of plant which has been found convenient and serviceable in preparing mixed acid.

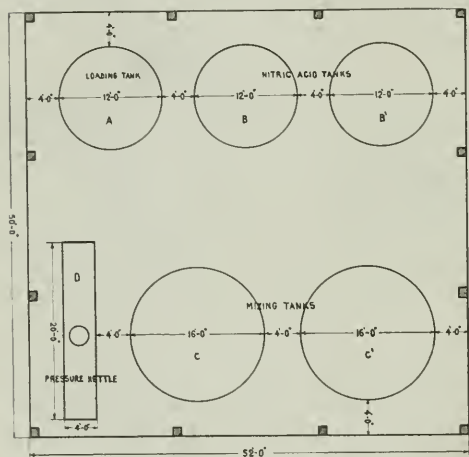


Plate A-1.

The operations are as follows: Sulphuric acid and nitric acid are carefully weighed separately, both are delivered into a large tank, stirred by compressed air and settled until clear. The clear mixed acids are decanted by a siphon and shipped in steel drums or tank cars. Facilities for weighing the acids accurately and for transferring them are required to be of the best and most convenient, because specifications often are close as to the percentage of variation in the mixture and careful adjustments of proportions must be made with economy of time.

Referring to Plates A1 and A2, the plan and elevation of a mixed acid plant, it will be easy to understand the general arrangement.

Sulphuric acid is received in the pressure kettle, *D*, weighed and delivered by compressed air into either of the mixing tanks, *C*, *C'*. The storage tank for sul-

phuric acid is not shown. This may be in any convenient location, with its outlet pipe connected to *D*. Nitric acid is received in the tank *B* (tank *B'* is a duplicate held in reserve), weighed and delivered by a gravity siphon into either of the tanks, *C* or *C'*.

The two acids are mixed by blowing with compressed air in *C* and *C'* and allowed to settle clear. The clear mixed acid is siphoned into the pressure kettle *D* and delivered into the loading tank *A*, from which it flows by gravity into either tank cars or drums for shipment.

The tanks, *C* and *C'*, have a bottom connection pipe into the pressure kettle, so that occasionally the sedi-

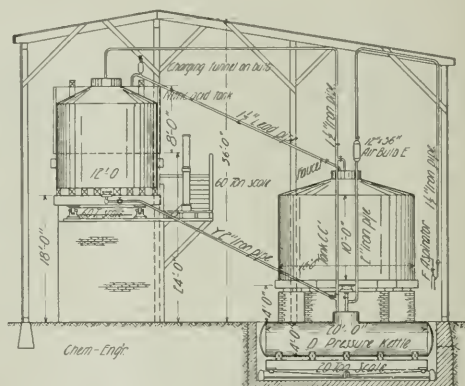


Plate A-2.

ment can be removed and delivered to the nitric acid plant for utilization and recovery of acid.

DESCRIPTION OF APPARATUS.

Tank *A* receives and weighs the finished mixed acid and delivers it into tank cars or drums for shipment. See Plates A1-A2-A7. This is a steel tank, built according to the specifications given at end of this article. A $1\frac{1}{2}$ " iron pipe brings the acid into the tank *A* from the pressure kettle *D*, as indicated in the plan, and a 2" iron pipe connected to the bottom of the tank carries the acid to the tank cars, or to the acid drums, by means of a 1" branch pipe. Asbestos packed iron stop cocks are used on these pipes. As a safeguard, a hard lead plug is provided to close the bottom pipe connection on the tank, and the plug is operated by means of a long iron handle extending to hole No. 2. This tank is provided with stoneware air vent as described hereafter for tanks *C* and *C'*. As to the head of dome of this tank, it is

also similar to that provided for tanks *C* and *C'*, and any unused openings are capped. A pipe to introduce compressed air into this tank is provided in the same manner as for tanks *C* and *C'*, for occasional use to stir the acid. A branch pipe from the car loading

capacity scale of the best make, supported on concrete or brick piers of sufficient strength to provide against any possible settling.

Tanks *B* and *B'* receive the nitric acid direct from the nitric acid plant. These tanks are built of steel,

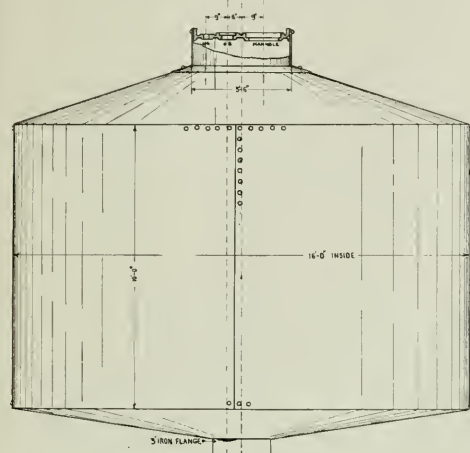


Plate A-3.
No. 2

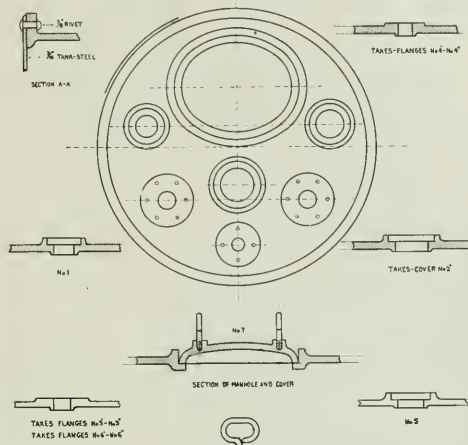
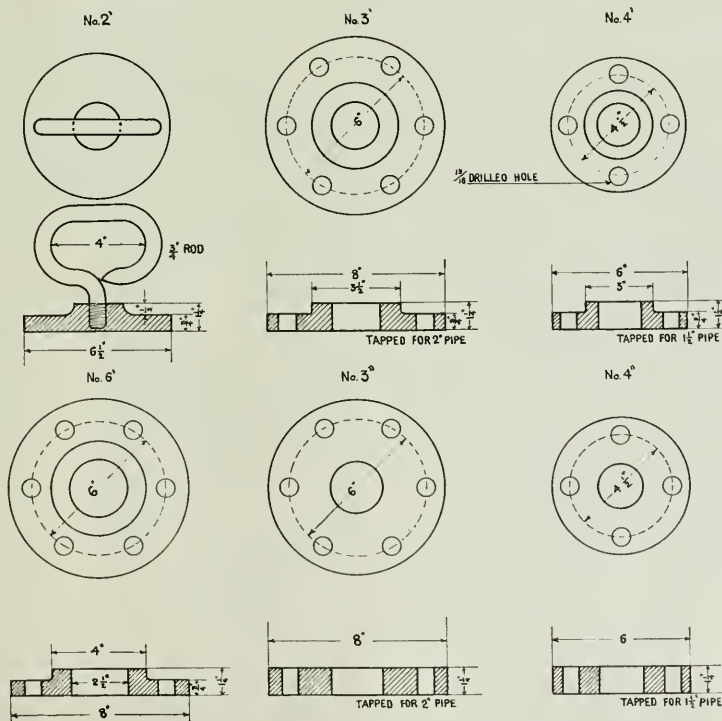


Plate A-4.
No. 4



tanks *C* and *C'*. A $\frac{3}{4}$ " lead pipe is provided for mixing the contents by agitating with compressed air. A $1\frac{1}{2}$ " lead pipe gravity siphon is provided as indicated—see Plate A2—for purpose of conveying nitric acid to mixing tanks, *C-C'*.

Tanks *C* and *C'*—See Plates A1-A2-A3-A4-A5. These are built of steel as per specifications given at

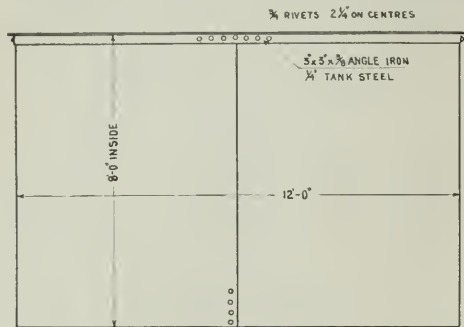


Plate A-6.

end of this article. They receive nitric acid from the tanks *B* and *B'*, also sulphuric acid which has been delivered from any source of supply and weighed in the pressure kettle, *D*, from which latter the sulphuric acid is forced into *C* and *C'* through a $1\frac{1}{2}$ " iron pipe entering top of *C* and *C'* by air pressure.

In tanks *C* and *C'* the nitric and sulphuric acids are mixed by agitating with compressed air and contents allowed to settle, after which the clear mixed acid is decanted by a gravity siphon into the pressure kettle *D* and thence raised into loading tank *A*.

The siphon is of 2" iron pipe and at its highest point a bulb made of a 36" length of 12" iron pipe, capped at both ends, is connected to the siphon, and a $\frac{1}{2}$ " iron pipe carried to a height not less than 35 ft. higher than top of tank and thence downward, is connected from top of bulb to an ordinary aspirator, operated by water pressure. This is used to create a vacuum which starts the siphon, while the height to which the $\frac{1}{2}$ " pipe is carried prevents acid from passing over to the aspirator. The above mentioned bulb on highest part of siphon is provided for purpose of collecting air and gas bubbles which displace part of acid in bulb, and thus the column of acid in the siphon is maintained for long periods in perfect condition, whereas without a bulb of liberal capacity the siphon is unreliable in operation. The foregoing remarks as to bulb apply also to any gravity siphon charged by means of a funnel and plug at its high point—viz., as for handling nitric acid, the funnel should be on top of the bulb.

Tanks *C-C'*—Details of Construction. Explanation relating to head of dome, see Plates A4-A5. The head is of cast iron and of a form found most convenient and durable. It is provided with several openings, described below.

Hole No. 1 is used for purpose of taking samples

and for measuring contents of tank and is closed by a cap similar to No. 2'.

Hole No. 2 allows access to an iron rod which is only required to be opened occasionally when sediment is to be run out of tank. This No. 2 hole is ordinarily covered with a cap, No. 2'. (See Plate A5.)

Hole No. 3 is provided with two flanges, the lower of which has a 2" iron pipe depending into the tank nearly to the bottom. It is customary to provide several such removable pipes of various lengths, to be used according to depth of clear acid found after settling. The upper flange receives the 2" iron siphon pipe extending to the pressure kettle. (See Plate A2.)

Hole No. 4 receives a $1\frac{1}{2}$ " iron pipe from pressure kettle *D*.

Hole No. 5 is connected by a 4" stoneware pipe to a couple of stoneware jars and thence to the outside of the building. This pipe is for the purpose of venting the air from tank. The jars serve to condense any moisture and acid spray.

Hole No. 6 receives the $1\frac{1}{2}$ " lead siphon delivering nitric acid from the tanks *B* and *B'*.

Tanks *C* and *C'* are provided with bottom outlets of 2" pipe, stopped with a long handled plug inside of the tank, as previously described; also these outlet pipes are provided with iron asbestos packed stop-

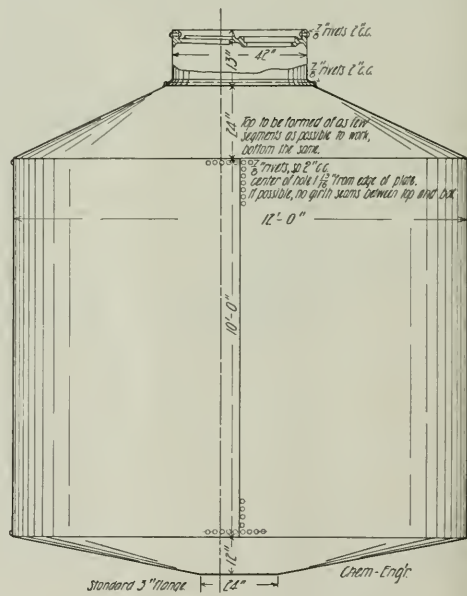


Plate A-7—Steel Tank for Mixed Acid.

cocks. The outlet pipes are connected with the pressure kettle *D* so that the entire contents of either tank can be drawn at pleasure into the pressure kettle and thus transferred into either tank. This is also done so that the mud settling out of the mixed acid in tanks *C* and *C'* may be periodically drawn off, and by means of a suitable branch pipe for the pressure

kettle delivered into any small steel tank that may be provided for the purpose of receiving the mud. Such a mud tank is usually located in the nitric acid plant, in a position convenient for running the mud into the nitric acid retorts.

The pressure kettle *D* consists of a strong steel

A3. To be built of 7/16" tank steel, using 3/8" rivets, spacing standard, single riveted. Sheets to be filed smooth on lap, so as to be free of burrs or scale. All seams to be chipped and caulked inside and outside of tank. Bottom and cover of tank to be formed of as few segments as convenient to work. Cover to be provided with a dome, also cast iron head manhole cover and flanges, as per Plate A4-A5. Bottom to be provided with steel flange threaded to receive a 2" iron pipe. Tank must be tested by filling with water and be made absolutely tight. No painting allowed until tested and accepted.

For construction of a steel tank for storage and loading of mixed acid. (Viz., tank *A*.) Dimensions and general form to be as shown in Plate A7. General specifications same as above. Cover and flanges as per Plates A4-A5.

For construction of a pressure kettle. Dimensions and general form as per Plate A8. To be built of 7/16" tank steel body and 9/16" heads well dished. To be provided with dome, also cast iron head, flanges, etc., as per Plate A9. Pressure kettle to be double riveted with 3/8" rivets, all seams chipped and caulked inside and outside, and, when completed, to be tested

tank (see Plate A8) located on a 20-ton scale. The dome of pressure kettle is provided with a cast iron head, as shown in Plate A9. This head is furnished with openings to accommodate the pipes for filling and discharging, also for the admission of compressed air.

The bottom of the pressure kettle *D* is provided

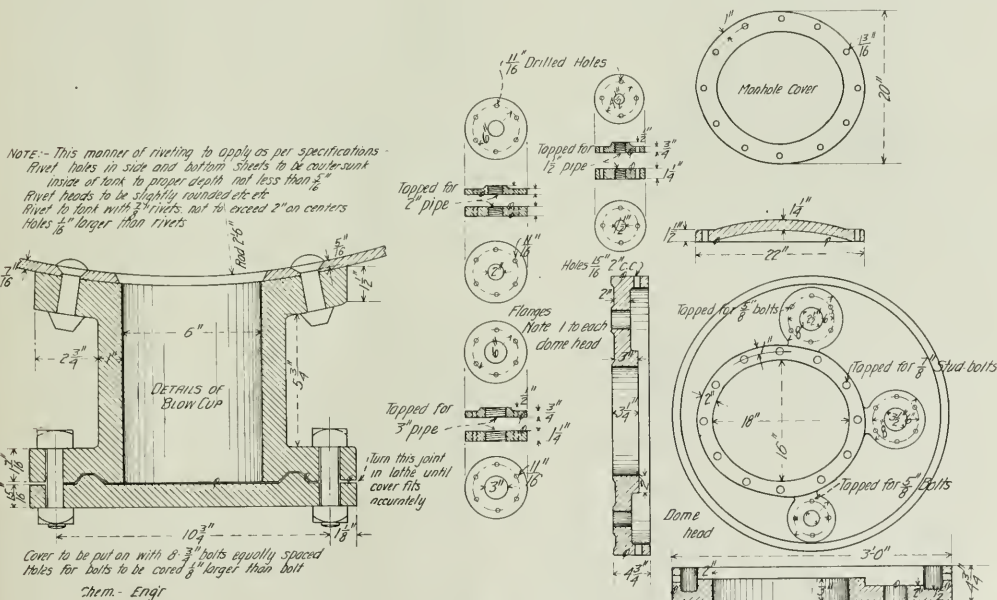


Plate A-9—Parts for Pressure Kettle D.

with a cast iron pocket. The discharge pipe entering through the head of this dome is made long enough to extend into this pocket and insure complete emptying of the pressure kettle.

SPECIFICATIONS.

For construction of a steel tank for mixing and storage of mixed acid. (Viz., tanks *C* and *C'*.) Dimensions and general form to be as shown in Plate

to 150 lbs. cold water pressure and made absolutely tight.

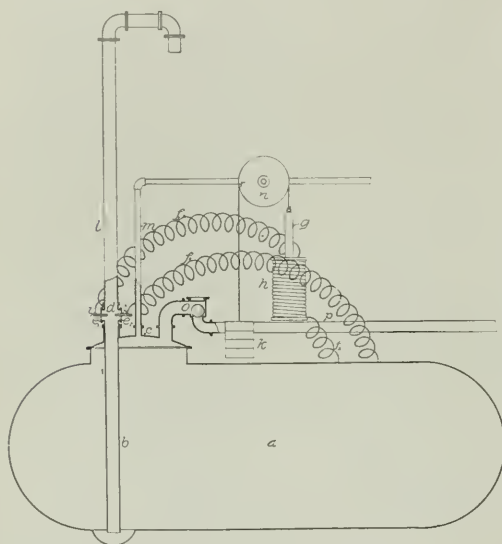
For construction of a tank for nitric acid (see Plate A6). Dimensions and general form as per Plate A6. To be built of 1/4" steel and made water tight. This tank is to be lined and covered with 16-lb. sheet lead; therefore the inside rivet heads must be countersunk and finished flush with shell.

AN AUTOMATIC ACID EGG.*

By RICHARD K. MEADE.

Chemical Engineer, Nazareth, Pa.

The elevation of acids is one of the most difficult problems which the chemical engineer has to solve. What has probably proved to be the most satisfactory method of doing this has been by means of the ordinary cast iron acid egg. The great objection to this apparatus is the constant attention which it requires. On the other hand, it does not get out of order and may always be relied upon to do the work. A number of automatic eggs have been placed upon the market. All of these depend upon a valve operated by a float. The difficulty with these automatic eggs has nearly always lain in the fact that they got out of order



Sketch of Automatic Acid Egg.

easily and that the float occasionally fails to operate the valve.

The following device has been used by the writer to lift sulphuric acid, and consists merely of a simple electrical attachment, which may be placed upon the ordinary cast iron egg, and which is designed to operate the valves, thus doing away with an attendant and so making the egg automatic in its action. It is shown in the accompanying illustration. *a* is the egg itself, *c* is the cast iron cover which is bolted to this. The acid enters by means of the pipe *p* and leaves by means of the pipe *b*. Air is conducted in by means of the pipe *m*. To the pipe *b* is bolted an ordinary cast iron cross *d* and to the side openings of this are fastened two porcelain plates *e*₁ and *e*₂. Into these pipes

are cemented two ordinary electric light carbons *i*₁ and *i*₂, and connected respectively by wires *f*₁ and *f*₂ with the electro-magnet *h* and with the source of current. The other wire *f*₃ of the magnet is connected with the source of current.

The working of the egg is as follows: The acid flows into the latter through the pipe *p* and ball valve *o* until the egg is full and it rises to a point above the carbon pencils *i*₁ and *i*₂. As soon as it does this, electrical connection is established and the electro-magnet pulls down a bar or core *g* of soft iron. This latter opens a valve *n* and allows the air to enter the egg. The check valve *o* closes, of course, as soon as air enters the egg and causes back pressure in the pipe *p*. The acid is also forced up the pipe *b*. As long as any acid is passing through this pipe the electrical current is, of course, passed through the magnet and the valve *m* is held open. As soon as the current stops the connection is broken and the valve is closed by means of the weight *k*. The valve *n* is made by simply taking off the wheel from an ordinary globe valve and replacing it by a wooden disc with a groove in the edge, in which the cord works. The cord is fastened to the disc at one point only, *r*. In place of the magnet, the connection may be made to start a motor-driven air compressor. The electrical current used for operating the egg may be either from the electric light current, or batteries may be used, and the magnet may be located at any convenient point where its workings may be observed. A counter may also be attached to the valve, and if the volume of the egg is known, the liquid so measured.

THE EFFECT OF CALCIUM ALUMINATES ON MORTARS.

Mr. Henry S. Spackman and Dr. E. W. Lazell, of Philadelphia, obtained some striking results by the incorporation of a small quantity of calcium aluminate with various mixtures composed of finely divided hydrated lime and ordinary clay, shale, sandstone or other silicious material. These mixtures, without the addition of the calcium aluminate, had absolutely no hydraulic properties, and possessed but little strength. The addition of the calcium aluminate developed in the mixtures pronounced hydraulic properties and gave them properties equal to those required for Portland cement. These gentlemen found that the setting time and strength of sand mortars made with these mixtures, could be regulated by the proportion of calcium aluminate used, and also by the use of suitable retarders, such as plaster of Paris.

The principal value of the calcium aluminate, as shown by these experiments, will unquestionably be in rendering hydrated lime hydraulic, and giving to mortars made with this, high strength in a short time. It is also probable that hydrated lime so treated, will prove a valuable wall plaster.

*Read at the meeting of the American Institute of Chemical Engineers, Brooklyn, N. Y., June 24, 1909.



ON THE DETERMINATION OF THE SO_2 LOSSES IN THE WASTE GASES OF THE CON- TACT PROCESS.*

By H. LJUNGH.

The sampling of the dry waste gases is done in the following way: A slow current of the gases is drawn through an absorption apparatus by means of an aspirator. The absorption apparatus is filled with 600 c.c. of half normal sodium hydrate solution and contains thus 12 grams of NaOH. After sufficient gas has been drawn through the apparatus (about 1000-1500 L.), the solution is transferred to a 1000 c.c. graduated flask and the latter is filled up with water to the graduation mark. A 30 c.c. portion of this solution (equal to $1/20$ of the original volume) is transferred to a 300 c.c. graduated flask and titrated in the same with a standard solution of hydrochloric acid, using methyl-orange as indicator. If n grms. free NaOH are found, the respective amount for the whole absorption solution is 20 n .

After adding two more drops of the standard acid solution, the flask is filled up to the graduation mark. The solution is now placed in a burette and allowed to run drop by drop in 100 c.c. $N/100$ iodine solution, to which starch solution has been added, till the blue color has entirely disappeared. It must be cautioned here not to reverse the operation, as the experience of Finkener, Volhard and others has proved that the result would be incorrect. If c c.c. of the absorption solution are used (of which 1 c.c. is equal to 0.032 grams SO_2), the SO_2 in the flasks would be equal to $1/c \times 300 \times 0.032$ grms., and therefore, in the whole absorption solution, $192/c$ grams SO_2 . This amount of SO_2 corresponds only to $40/64 \times 192/c = 120/c$ grams NaOH. This is explained as the sulphite of soda is changed into bisulphite during the first titration with hydrochloric acid. Therefore, $12-20n-120/c$ grams NaOH are used to combine with the equal amount of SO_3 (by the equation $2\text{NaOH} + \text{SO}_3 = \text{Na}_2\text{SO}_3 + \text{H}_2\text{O}$), which is absorbed from the aspirated gas volume V liter (at 0°C . and 760 mm. pressure). The relatively small volume of dissolved gases can be neglected in this calculation. From a kilogram of sulphur actually burnt in 24 hours $2a$ kilograms of SO_2 should be obtained. But from this amount a certain percentage, $k\%$, must be deducted, which represents principally SO_3 as condensed acid in coolers, filters, etc., and this value must be determined individually in every plant by direct measurements. Therefore, a kilogram of sulphur burnt in the furnace yields

$a/50.(100-k)$ kg. SO_2 . As the weight of 0.348 cu.m. SO_2 at 0°C . and 760 mm. pressure is 1000 kilogram, the weight of 0.00696 $a.(100-k)$ cu.m. at 0°C . and 760 mm. pressure will be equal to $a/50.(100-k)$ kg. Now, if the SO_2 gas represents p volume per cent of the total gas mixture W , then $p W'/100 = 0.00696 a.(100-k)$ and $W' = 0.696a.(100-k)$ cu.m. at 0°C .

and 760 mm. pressure. If the yield or conversion in the contract mass is $u\%$ of the SO_2 gas, i. e. $u/100 \times 0.00696a (100-k)$ cu. m., then another one-half as large volume of oxygen gas will be required for the formation of SO_3 . Then, if $(100-f)\%$ of the SO_3 gas are collected in the absorption apparatus, the amount of escaping gas will be

$$\frac{100-f}{100} \times \frac{1.5u}{100} = 0.00696a(100-k) \text{ cu. m. gas.}$$

The actual loss (x) of SO_3 can now be calculated as follows; to simplify matters the found SO_3 amount $(12-20n-120/c)$ is stated as S grams:

$$\frac{0.696a (100-k)}{p} - \frac{100-f}{100} \times \frac{1.5u}{100} = \frac{S}{0.00696a (100-k)} = V$$

or $x = \frac{f}{100} \times \frac{1.5u}{100} \times 0.00696a (100-k) \times 2.78 \times 1.2932 \text{ kg} \times \text{SO}_3$

(2.78 is the calculated specific gravity of the SO_3 gas; 1.2932 is the weight in kg. of 1 cu.m. air at 0°C and 760 mm Hg. - pressure.)

By eliminating the unknown constant f the result is

$$x = \frac{2.5a (100-k) \left(\frac{1}{p} - 0.00015u \right) s \text{ kg, SO}_3}{3.6 V - s.}$$

In proportion to $3.6V$, s is of small value (for instance 4 : 3600), and can therefore be eliminated from the denominator; moreover, as the volume V is estimated too small. The loss (F) expressed in per cent of the amount of SO_3 which can be obtained theoretically from the quantity of sulphur burnt, is calculated as follows:

$$F = \frac{100x}{80} = 40 \frac{x}{a}, \text{ or } F = \frac{(100-k) \left(\frac{100}{p} - 0.015u \right) s}{3.6 V} \%$$

$k = \%$ SO_2 condensed as acid in coolers, filters, etc.;

*Translated from Chemiker-Zeitung, XXXIII, 17, 142.

p = vol.-% SO_2 in pure and dry roast gas; u = % SO_2 transformed into SO_3 by the contact mass; l = liter gas aspirated from the waste gases and reduced to 0°C . and 760 mm. pressure; s = grms. SO_3 in the same gas volume, l liter.

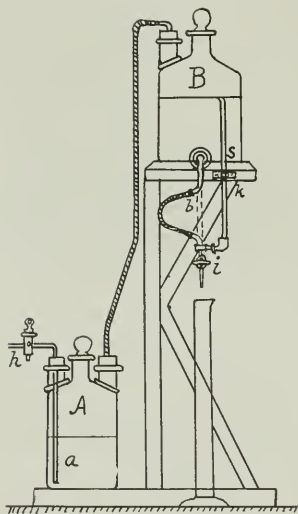
From the 600 cc. half normal sodium hydrate solution in the absorption apparatus, an equivalent of — 192

grams SO_2 + s grams SO_3 were absorbed. 1 gram SO_2 = 0.35 liter gas, and 1 gram SO_3 = 0.28 liter gas at 0°C . and 160 mm. pressure. The volumes of 66

the absorbed gases are therefore about — + 0.35 liter. c

In conclusion, a simple method for the estimation of the pressure correction for the exact determination of the SO_2 contents in roast gases by means of Reich's apparatus, will be given.

In a number of sulphuric acid plants which employ



roast gas mixtures under pressure, a modification of Reich's method has been accepted. The usual application of the gas entering tube of the reaction flask as manometer would be impractical in such tests on account of the high pressure. Therefore the control cock h is placed on the respective inlet tube a and the water column between the water level of the upper bottle and the point of the outlet tube b serves as manometer. When a fresh amount of gas enters, the column sinks lower, and after the atmospheric pressure is balanced, the dilution of the enclosed gases is less than before, this causing the measuring error which must be corrected in an exact determination. But as it depends on the changing gas volume of the two bottles, the correction can be made by the following mechanical device.

The exit tube b is cut in the center and the ends are bent to one side and connected again by means of a long, heavy wall rubber tubing. The tube with cock i , which is free to move, is now fastened to the extremity of a vertical metal rod s , by means of a clamp. This rod, which can be conveniently turned in its vertical direction, ends in a point, bent at a right angle, to correspond with the changing water level of the bottle B. By means of a clamp screw, k , the whole apparatus is held at a convenient height.

In an SO_2 determination, the manipulation is as follows:

1. By opening the three-way cock h , the inlet tube is filled with fresh gas, at the same time the measured quantity of iodine can be placed in the bottle A. After the bottle is closed, the cock i is opened and the point of the rod s is placed to correspond exactly with the water level of the bottle B.

2. By turning the cock h , the gas current is allowed to enter the iodine solution through the narrow tube a . The unabsorbed gas passes out and thereby causes water to run from the bottle B in a measuring cylinder which is placed underneath. As soon as the iodine starch solution is discolored, the cock h is closed again and the water stops to run from B.

3. The rod point is placed again corresponding to the new water level, whereby more water runs out.

In practice, if temperature and barometer conditions are not considered, it would not be practical to make this correction, as it takes course in opposite direction of that of the temperature. But as in the above mentioned arrangement the height of the aspirating water column remains constant, the barometer pressure correction is also simplified. A correction table for the pressure correction of roast gases, which are within very narrow limits of fluctuation in the volume percent composition, could thus be easily prepared.

The new laboratory of the Delaware, Lackawanna & Western Railroad, at Scranton, Penn., with its fixtures, will have cost about \$40,000 when complete in detail. Testing machines for metals, cement, wood and rubber hose are in place, including a Reihle 200,000-lb. machine. There are fine soapstone topped chemical benches on the second floor, with a complete system of hoods, and other methods of ventilation.

According to the New York *Sin*, the largest order for radium ever given has just been placed jointly by Lord Iveagh and Sir Ernest Cassel, who will donate it to the Radium Institute for the foundation of which they have provided the funds. The quantity ordered is $7\frac{1}{8}$ grams—about $\frac{1}{4}$ oz. avoirdupois—and the price is \$150,000. The largest amount previously bought at one time was 1 gram. The order was given to the British Metalliferous Mines Company, which will obtain it from the Cornish pitchblende deposits under the superintendence of Prof. Giesel, the company's chief chemist.

A COMPRESSED AIR WASH-BOTTLE.*

By EDWIN DOWZARD.

Analytical Department, Parke, Davis & Co., Detroit.

In laboratories where a supply of compressed air is available, the apparatus about to be described will be found of value.

The apparatus consists of a flask of suitable size (as the latter is stationary when in use, a flask of two or three liters capacity may be used), provided with a rubber stopper with two perforations. Through one of the perforations a limb of the T piece *A* passes, the horizontal portion of which should be about twice the diameter of the vertical. Through the other perforation passes a tube, *B*, which nearly touches the bottom

perforated rubber stopper, *I*. A piece of copper wire provided with a hook is attached to the tube, *H*, so that the latter may be suspended from the wire, *J*, which is attached to the flask. The end of the T piece, *A*, is connected with the compressed air main by means of rubber tubing. When the compressed air is turned on, it passes through the horizontal portion of T piece *A*, then through T piece *C*, and leaves the apparatus at the hole *H*. When the apparatus is in use the thumb of the right hand is placed over *H*, the compressed air then passes through the vertical limb of T piece *A*, into the flask, and forces the water through the jet *F*.

Very little compressed air is required by this apparatus. If the air is turned on in the morning, the apparatus may be used at any time by simply placing the thumb over *H*. The force of the jet may be easily regulated by allowing part of the air to escape at *H*.

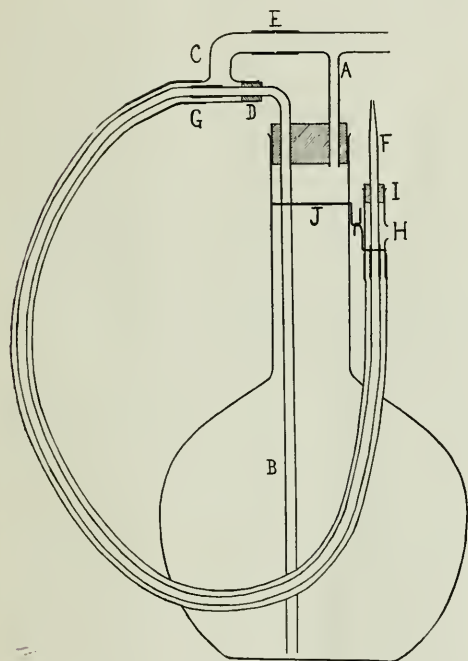
This apparatus is very convenient for washing precipitates, etc., as the jet of water may be sent in any direction by a slight turn of the wrist.

Efficiency of a dryer is the theoretical heat required to do the drying, less the loss of heat. These losses are but three, the greatest being the heat carried out by the exhaust or waste gases; this may be as great as 40% of the total heat from the fuel, or, with a properly designed dryer, be as small as 8%. The next greatest loss is by radiation from shell or walls. This may be as high as 25%, or as low as 4. The smallest loss is due to unnecessary heat carried away by the dried material. This may amount, under certain conditions, to as much as 25% or as low as nothing. Whatever loss there is, however, is generally due to careless operation.

The Belgian steel works of the Cockerill Co., in Liege, have just started an electric furnace, which is built on the Giroud system, with one electrode, and has a charging capacity of from two to three tons of steel. The dynamos furnishing the necessary electric current—an alternating current of 50 volts—are operated by gas motors, utilizing the gas from the blast furnaces. The electric furnace is placed in a building in close proximity to the steel converters, with which it is connected by a traveling crane, with a truck for transporting the ladles to the converters.

The Electro Mechanical Engineering Bureau, Chicago, which opened laboratories and offices in the Monadnock block some months ago, has now incorporated in its laboratory facilities features which enable it to make complete and guaranteed analysis on fuels, oils, cements, steels, food products, sewage, water, etc. The bureau during the last few months has been extremely busy, its work having been mainly along the above lines.

Germany in 1908 produced 20,000 tons of steel by the electric furnace.



Sketch of Compressed Air Wash Bottle.

of the flask. The part outside the flask passes through the horizontal limb of the T piece *C*, and is held in position by the perforated rubber stopper, *D*. The vertical limb of the T piece *C*, is connected with *A* by means of a piece of rubber tubing, *E*. To the end of the tube *B*, which passes through the T piece *C*, is attached any desired length of narrow rubber tubing; two feet is a convenient length, although any length may be used. A glass jet, *F*, is attached to the end of the tubing. A piece of rubber tubing about twice the diameter of the narrow tubing is passed over the latter and attached to the T piece *C*, at *G*. The other end is attached to a piece of glass tubing, *H*, in the side of which a hole about 6 mm. in diameter has been blown. The jet, *F*, is fixed firmly in this tube by means of the

*American Journal of Pharmacy, April, 1909.

METALLURGY.

THE PRACTICAL VALUE OF CHEMICAL STANDARDS FOR IRON CASTINGS.*

By JOHN JERMAIN PORTER,

Professor of Metallurgy, University of Cincinnati.

In the final analysis, the test of a successful foundry is its ability to make money for its owners, and the three factors which determine its success are: 1st, ability to make good castings; 2d, the ability to make good castings cheaply; 3d, ability to sell its product at fair prices. Since the composition of the metal going into the castings has a large influence on both the first and the 2d of these factors, we may perhaps be pardoned for again unearthing this ancient subject and may be permitted to consider it in its direct relationship to the commercial success of the foundry.

There are four factors on which the quality of a casting depends: the chemical composition; the treatment which the metal has received in melting; the heat treatment, i. e., casting temperature and rate of cooling; and the perfection of the mold. These four factors are probably of nearly equal importance and each of them is deserving of far more systematic and extended study than has yet been given it.

The cost of castings is not so greatly influenced by their composition and is perhaps chiefly a problem in the making of molds. In certain cases, however, it may play an important part, since the number of wasters or spoiled castings is often closely associated with the composition of the metal and, as all foundrymen know, there is nothing which will send the cost up so rapidly as a large percentage of bad castings.

The cost is also influenced by the chemical composition of the metal in another way. That is, by the cost of the iron used. This comes about from the fact that for any given casting there will be several different compositions, or perhaps a wide range in composition, any one of which is equally good. Some one of these, however, will be cheaper than the rest and hence the foundryman who works according to analysis and with full knowledge of his requirements in the way of composition can effect a saving in cost which, though small, is not unimportant.

As an example of this, I would mention the case of the ordinary run of machine tool castings which are so commonly made in the foundries of this district. These castings are of medium thickness and must be soft enough to machine. Owing to the fact that the foundry is not commonly considered to have any rights that the machine shop is bound to respect, our foundry superintendents have had it most firmly impressed upon them that no crime is so heinous as that

of turning out hard castings, and hence the custom has grown up of using from .25 to .50% more silicon in these castings than is necessary in order to insure immunity from machine shop kicks. In other words, 2.25% to 2.50% silicon is very frequently used in work where 2% is quite sufficient. Now, if we examine the market reports of the price of pig iron, we find that there is an average difference of 50 cents per grade number per ton of pig iron; i. e., if No. 2 sells for \$14.75, No. 1 will sell for \$15.25. It is also a fact that the grade numbers represent a variation of 50% of silicon, i. e., No. 2 averages 2.25% and No. 1 2.75%. Thus it may be said that each .01% silicon costs 1c and if we use .25% more silicon than is necessary in our mix, we unnecessarily increase the cost of our metal just 25c per ton.

This may seem like a small thing, adding, as it does, only one-eightieth of a cent per pound to the cost of the castings, yet, when we consider that the excessive amount of silicon used has a very injurious effect in the way of producing dirty iron and porous places in the heavy sections, and thus is sometimes accountable for a considerable number of spoiled castings, the point does not seem so trivial.

Another case is found in the extensive use of manganese by some of our best informed managers who have learned to appreciate its excellent effects in giving clean, sound iron, and in reducing the scrap pile. One of my foundry friends tells me that by the use of high manganese pig iron he is enabled to use large amounts of very cheap high sulphur pig, the manganese counteracting the injurious effects of the sulphur and being itself comparatively inexpensive.

This same friend also says that he has not had a ton of No. 2 iron on his yard for months, his requirements being obtained by mixing a cheap high silicon high sulphur iron with other cheap low silicon high manganese irons. Of course with this procedure, very close attention to the details of charging and the methods of receiving the iron in ladles is necessary, but the fact that it can be and is done successfully is worthy of careful attention by our members.

An erroneous idea, resulting from lack of confidence in the competency of mixing purely on the basis of chemical composition, is held by some foundrymen in the middle west. These men will tell you that it is very difficult to make satisfactory castings from northern iron or southern iron alone but that a mixture of northern and southern brands is necessary for satisfactory results. No doubt this idea had its origin in the days when the grading of pig iron was done entirely by fracture. Southern pig iron averages high in silicon, sulphur and phosphorus. Northern iron

*Read before the American Foundrymen's Association at Cincinnati meeting.

averages low in these same elements. Hence by a mixture of these two, a happy medium was usually obtained. However, there are some brands of southern iron which are low in phosphorus and which may be obtained with any desired silicon and sulphur, and by the use of these southern irons of correct composition just as good castings may be made as though a mixture of northern and southern iron giving the same composition were used. The advantage of this knowledge lies in the fact that southern iron can usually be obtained at a somewhat lower price than northern iron for corresponding grade numbers. At the present time the difference, in this market, is only 20c. per ton as between northern and southern No. 2, but this difference is sometimes as high as \$1.50 per ton, so that an important economy is open to the man who understands mixing by analysis and is not afraid to use the largest possible proportion of southern pig.

Many other examples might be cited showing the heavy penalty paid by some operators for their lack of knowledge of this subject, or lack of appreciation of its importance, and it is probable that there are but few plants where some improvement in cost or quality could not be made if all the information available were applied.

This naturally brings us to the reason why our knowledge of foundry metallurgy is not more generally used since foundry operators are certainly not less enterprising or less desirous of economically conducting their business than we technical men who try to tell them how to do it. The answer to this question, may, I think, be found in the fact that the various data have not been gotten together in such form that the practical foundrymen can readily use them. It is well known that within recent years, especially, vast additions have been made to our store of information regarding cast iron, but two facts militate against the use of most of it. The first of these is that but little of this material has been gathered together in handbooks or in such form as to be readily available for use. Most of it, and that the most valuable part, has been published in the various technical journals, and the foundryman who wishes to find the best kind of iron for making hydraulic cylinders, for example, would have to search through the files of perhaps a half dozen journals, and it might take him two or three days to dig out all the information available on the subject. The other factor is that so much of the material published is written up from the scientific point of view rather than the practical, and hence is not in a form to be understood and applied by the foundryman who has neither the time nor inclination to dig out the meaning of the diagrams, micro-photographs, and long-winded scientific explanations offered.

It is true that this scientific work is of the highest importance, indirectly, but it needs to be thoroughly digested, correlated with practical experience and the results restated in ordinary foundry language in order to make it available for practical use. There has also

been done an enormous amount of technical experimental work which fails to be of value because of incompleteness, for example, data connecting the strength of iron with varying percentages of silicon are meaningless unless the percentages of other elements are also given. Moreover, statements that an iron of a given composition has such and such a strength is of very little use taken by itself since the value of a casting is seldom dependent upon strength alone and there are many other properties of cast iron, such as hardness, shrinkage, density, etc., which must also be considered.

Looking at it from this standpoint, it will be seen that the problem is very complex and not to be approached lightly. Some twenty different physical properties of cast iron may be enumerated which influence its value and adaptability for the manifold purposes for which castings are used. Cast iron may be regarded as an alloy of six elements, i. e., iron, carbon, silicon, sulphur, phosphorus and manganese, and since these elements may be combined in various ways, we may have some twelve or fifteen different constituents. Now, since each separate constituent has or may have a specific effect on each of the twenty physical properties, it will be readily seen that if the problem is to be investigated systematically from start to finish an almost infinite amount of work will be required. To illustrate: if each of the six elements is varied in only seven proportions and each resulting metal tested for each of the twenty physical properties, 2,352,980 different experiments will be required. Evidently, then, any such review of the field as outlined here is entirely impossible at the present time.

As a matter of fact, such an accumulation of data would, after all, give us only half the information we require, since in a great many, perhaps the majority of cases, the exact physical properties which are necessary to make the best casting of any particular class are not well defined. For example, to take the case of a foundryman making hydraulic cylinders, even supposing that he had all this data at his command, it could not aid him unless he knew also, exactly what degrees of hardness, strength, density, etc., are most desirable in his cylinder.

Evidently, then, the most feasible way of placing this metallurgical data before the foundryman in such form as to make it of practical value, is to first classify castings according to the physical properties which are of importance in them, and then to tabulate the chemical compositions which are found suitable for each class. It would also be highly desirable to take some cognizance of the factor of the cost of the mixture and show, where possible, how the foundryman could cut down the cost of his iron without decreasing the quality of his product.

An investigation carried out along these lines, while involving considerable work, would not be impossible and would certainly be of immediate and direct benefit to the foundry industry. The data needed could be obtained very largely from material already pub-

lished and from inquiry among plants making the various lines of castings. Some experimental work would undoubtedly be needed to fill in the gaps, but I do not believe that it would be very great in amount.

With regard to the classification of castings, Thomas D. West has outlined a system of classification and divided castings into thirty-four classes.* I have not yet looked carefully into this phase of my subject and am therefore unable to say if this classification would be suitable for our purpose or whether a more or less detailed classification or a classification along different lines would be necessary.

In conclusion, it appears to me highly desirable that this subject be taken up by the American Foundrymen's Association and added to the number of those foundry matters which have been threshed out, systematized and standardized under our auspices. I therefore urge that this meeting take under careful consideration the advisability of appointing a committee for the formulation of chemical standards for iron castings.

*"Suggestions for Procedure in Formulating Standards for General Castings." Trans. Amer. Society Testing Materials, 1903.

THE MANUFACTURE OF PHOSPHOR-TIN.

The ordinary method of making phosphor-tin is to introduce the phosphorus into the molten tin by means of a black lead phosphorizer. This method is not, however, as satisfactory as the following plan:

Sponge tin is prepared by melting pure Straits tin and pouring it from a height of several feet into a bosh or tub supplied with running water. The sponge tin is then removed and thoroughly dried, or the tin may be prepared in the form of fine shavings.

The phosphorus used is the yellow cake phosphorus made and supplied in one or two-pound cakes. These cakes are placed in a saturated solution of copper sulphate for about ten minutes, shortly before they are used. This gives them a very thin coating of metallic copper so that they may be handled with safety, and they are dried by rolling in sawdust.

The requisite amount of phosphorus (5% is the usual content for phosphor-tin) is placed in the bottom of a black lead crucible, covered with the dry, sponge tin, some powdered charcoal added and the lid of the crucible tightly mudded on with a mixture of loam and fireclay. The crucible is heated with a slow heat until the phosphorus has cut the tin and combined with it. The resulting phosphor-tin is then skimmed and poured into suitable molds, preferably of small size, and set in running water like solder molds.—*The Metal Industries.*

According to Bennie it is probable that the principal improvements in electrical steel furnaces will be along the following lines: (1) electrodes of larger size; (2) refractory materials superior to those now in use; (3) increase in size and capacity of the furnace.

THE USE OF STEEL SCRAP IN THE CUPOLA.*

By C. R. MCGAHEY.

Richmond, Va.

The foundryman of today is confronted with the problem of what kind of cast iron he shall try to make. Whether to go into irons that show greater elasticity and strength, or to stick to softness regardless of what the work is intended for.

In working on this problem myself, I took for my standard for comparison a test bar longer than the ordinary, as this did not run the breaking strengths too high, and also gave deflections more readily observable than with the ordinary 1¼" round bar broken on supports 12" apart.

My tests ran from 750 pounds up to 2,400, with a 1" by 1" by 24" bar, separately cast—not as a coupon. The deflections approximated from 0.10" up to 0.55". This range obtained with all kinds of iron in the ordinary run of shop work is not at all satisfactory, and it would seem that some point ought to be selected to which foundrymen should work in order to get the most satisfactory product in regular jobbing castings—not special work.

To best resist repeated strains, shock, and heavy work, it is necessary to run the elastic limit up as high as possible and yet hold a good deflection. Since the breaking strength and elastic limit in cast iron are not far apart, we would naturally try to get our transverse test quite high, and for the bar in question aim at 2,000 lbs. and perhaps even higher, the deflection running up to 0.50".

It is further necessary to reduce the shrinkage to a minimum, so that the interior strains may be obviated as much as possible. This is particularly the case where pulleys, fly wheels, and the like are made. A careful study of chemistry of iron will assist in this, and the addition of steel to the mixture, thus reducing the total carbon, gives us the best solution. In this way it is possible to run up the strength of the bar 70% and also greatly increase the deflection.

The terms semi-steel and ferro-carbon, while used with good intentions are entirely misleading, as we do not convert the iron charged to steel or anything like steel, but simply dissolve the steel scrap added in the iron mixture, making it of higher strength. It is cast iron just the same.

Now in using steel scrap, much depends upon the coke for the fuel. I have found that with mixtures of the same composition and make up, with one coke I would get a high strength, and with another quite the reverse. The melting conditions were exactly the same, and the peculiar results are doubtless due to the composition, structure, and behavior of the coke in the cupola, causing the iron to melt more or less fast and remain in contact with the fuel to a greater or less extent. Thus a coke with a low ash—or in other words high fixed carbon—gave a very hot looking iron, but with a much lower transverse

*Read before the American Foundrymen's Association at Cincinnati meeting.

strength than another coke higher in ash, but with the same sulphur (0.54). The addition of more steel scrap to the better coke gave the strength more nearly equal to the other metal, showing evidently a greater absorption of carbon from the fuel with the better coke and hotter metal.

It is therefore necessary to understand the fuel and melting conditions well in order to obtain desired results. It is further necessary to run quite hot, and when much sulphur is present, to carry high manganese as this tends to flux off the sulphur as a manganese sulphide. A very interesting observation was made when an accident stopped operations for a short time. The test bars made from the metal right after starting up again ran very much better than the average of the run. It seems as if the stoppage gave the steel time to get very highly heated up, and hence it melted more readily, thus producing lower carbon cast iron, with consequent higher strength.

To get the materials of the charge to mix well is very desirable. I have had the best results when allowing the bed to burn for two hours—having it heavy enough to allow this—then to use very mild blast (from five to six ounces only). This always gave me higher strengths than when I used an eight ounce blast or higher. If time is given for the steel to melt and mix with the cast iron, the total carbon will be lower than if the cast iron of the mixture flows by the steel fast and has no chance to unite. For this reason also it is better to place the chunky pieces of steel low down, and the smaller pieces above. This allows the cast iron to wash it as it goes down, and unite with the steel, making a low carbon cast iron with consequent strength.

The reduction of the total carbon by steel additions makes the resulting castings very much denser. If now the sulphur is controlled by hot melting and high enough manganese, and the phosphorus kept down (my best work has been with phosphorus about 0.230) very serviceable castings are made.

Another point that will be seen in this steel scrap addition melting is the rather great irregularity of the silicon reduction in hot runs, and in the sulphur content. The latter will vary very much indeed. Silicon, on the other hand, usually runs about 0.25 loss in normal heats, but is much greater if the temperature gets up fast. The deflection is better when the sulphur is down.

The following are some results that may be of interest: Metal which would have about $\frac{3}{4}$ " chill and be entirely gray when cast in sand, in the 1" square section, had silicon 0.82, sulphur 0.097, phosphorus 0.23, and manganese 0.54. This metal in a bar 1"x1"x24" broke at 1,800 lbs. with a deflection of 0.38". The percentage of steel carried was 7. The coke used contained sulphur 0.54, phosphorus 0.63, fixed carbon 92.53 per cent.

Another test gave Si. 0.88, S. 0.081, P. 0.24, Mn. 0.67. The test bar broke at 2,200 lbs. with 0.40" deflection, and the charge contained 20% steel.

A third test gave Si. 0.58, S. 0.097, P. 0.25, Mn. 0.44, and the bar broke at 2,250 lbs. with 0.48" deflection, and had 23% steel scrap (structural shapes).

Another good mixture gave Si. 0.79, S. 0.081, P. 0.239, and Mn. 0.04. This carried 21½% steel scrap.

I find that to get the strongest bars, I have to keep pretty close to these analyses, and have made my strongest bar at 2,350 lbs., 0.55" deflection. The iron had a fine grain, was low in graphite, but machined nicely.

When ferromanganese was used, about 1½% was found to be best. The above resulting compositions (the silicons of the mixtures being calculated to bring them about) are intended for castings ranging from 1" to 2½" in section. Should heavier work be required it is better to run the silicon in the pig up to 2.75, and the manganese up to 2.00, and to use 33¼% steel scrap.

I hope that these few hints may be of value to the foundryman looking for strong and yet elastic irons.

SOFT SOLDER.

The best mixture for the soft solder containing cadmium has been found to be the following: Tin, 50 per cent (2 parts); lead, 25 per cent (1 part); cadmium, 25 per cent (1 part). The metals are melted together and a small quantity of sal-ammoniac is used on the surface as a flux. This cleans it well. Before pouring into bars, the solder should be well stirred in order to thoroughly mix the metals. The cadmium increases the strength of the solder. The melting point of this cadmium solder was carefully tested by means of an accurate thermometer and found to be 292.1 deg. F. (144.5 deg. C.). This is about 30 deg. lower than the best solder composed of two parts of tin and one part of lead.

As cadmium is now not very expensive, the cost of the solder is not increased very much. It will be found useful for soldering soft metals such as britannia, pewter, antimonial lead and similar metals of a low melting point, and will tend to render the soldering operation much safer, as there is less danger of melting the metal to be soldered.

Steam is often injected into large vats or tanks for the purpose of agitating solutions and in some cases heating them. Better results may often be obtained by mixing air with the steam, particularly where all that is desired is the agitation of the contents of the vat, as better agitation is secured, the contents of the tank become less diluted, and there is a large saving in the amount of steam employed. The mixing of the air and steam may be effected by cutting in a Garfield injector. In operation the steam is first turned on, then the valve of the injector is partly opened until the right amount of air is obtained. An excess of air should be avoided where it is desired to keep the contents of the tank at a given temperature, and this may be controlled by means of a thermometer.

CASTING IRON IN PERMANENT MOLDS.

Mr. Edgar A. Custer, President Tacony Iron Co., has given a most interesting account of the practice at his plant during the past three years of casting iron in permanent molds.* The material used for these molds is cast iron, though the practice in using them is not to confound with that of chill casting. The molds are made rather massive for the sake of retaining their shape under the temperature strains, and so that the heat will be removed from the casting as rapidly as possible. The molds are not lined with a non-conducting material, but are given a thin coat of graphite in oil to prevent the casting from sticking.

It is shown that the chilling effect under the Tacony Iron Company's practice does not produce white cast iron. This is prevented by removing the casting from the mold as soon as it has set, and allowing the cooling from this point to proceed slowly. It has further been shown that the internal strains imposed upon the ordinary chilled casting are greatly reduced and that segregation is minimized. In order to obtain good results the iron must be poured at a high temperature.

Castings made in this way are exceedingly strong and tough, and may be tempered like steel. They are also close grained and remarkably free from blow-holes. Chemically, they are similar to cast iron, except for the combined carbon they contain. Some explanation is here offered. Supposing all the carbon in molten cast iron to be in the combined form, it will remain as such if the iron is instantly cooled. If cooled quickly to the setting point and then allowed to cool slowly, the carbon will be in the combined form at the time of setting, but will subsequently pass largely into the free state. The rapidity of this change is shown by the following analysis of two pieces from the same lot of iron:

	Combined Carbon	Total Carbon
Cast in sand and cooled normally.....	0.27	3.20
Taken from permanent mold at bright yellow heat and quenched.....	1.50	3.02
Taken from permanent mold at bright red heat and quenched.....	0.49	3.10

While the carbon is shown to exist chiefly as graphite it is not like the graphite in ordinary cast iron, but partakes more of the character of annealed carbon. The great strength and toughness of permanent mold castings is probably due more to the condition of this carbon than to anything else. The evils due to sulphur and phosphorus are mitigated in permanent mold castings. This, according to the writer's view, is due to the fact that segregation is checked to so great an extent. He thinks that this influence is due not simply to their presence but to the fact that they segregate in ordinary castings.

The permanent mold has its limitations in the thickness of the sections of castings. Thick castings would require too long to cool, allowing segregation to take

place. Pipes and any shapes requiring cores may be made, provided of course, that the shape permits of the core being withdrawn after the metal has set. Pipes cast by the above process were easily turned and threaded without annealing.

The weight of a permanent mold should be somewhat proportional to the weight of the casting. When a core is needed it is made of the same material as the mold. The life of a mold is not known. The writer states that so far 6,000 pieces have been cast, leaving the mold in better shape than when put into use.

The possibility of using permanent molds for direct iron is suggested. The initial high temperature of iron direct from the furnace would be an advantage.

The Harmet process for compressing fluid ingots is now most favored throughout Europe. There have been installed 50 or more presses, ranging from 450 to 7,000 tons, for ingots from one to 50 tons. The Harmet process consists in exerting the pressure upon the base of the solidifying ingot which is held in a strong, tapering mold.

Elimination of Fuels.

This line of improvement has for the most part yet to be worked out. The wonderful growth of electric power development which the past 25 years have witnessed, and especially the past 10 years, promises a more radical method for reducing fuel consumption than any that has ever been tried or thought of. Fuel costs have been cut down half by other methods, electric processes may cut down the present consumption in different operations from 50 to 100 per cent. It is stated by good authority that the electric power developed by the Niagara Falls Power Company alone displaces 1,000,000 tons of coal annually. With the harnessing of the rivers of the United States what has the future to witness?

The standard abrasion test for road-metal as adopted by the American Society for Testing Materials requires 30 lb. of coarsely broken stone to be available, and that there shall be placed in the cylinder as nearly as may be, 50 pieces weighing 11 lb. The cylinder is placed at an angle of 30° with the axis of rotation. The cover on the cylinder being tight fitting, the material is thrown from one end of the cylinder to the other, this continuing for 10,000 revolutions at the rate of 30 to 33 per minute. At the end of the test the worn material is the part which is fine enough to pass through a sieve having 1/16-in. mesh. The percentage of wear may be used in comparing different materials, or the French coefficient of wear, which is $400 \div W$. W is the weight in grams of detritus under 1/16-in. per kilogram of rock used.

It is announced that the American Agricultural Chemical Co. has secured control of the Sollsted Mine, one of the largest potash producers in Germany.

*Iron Age, 83, 20, p. 1581.

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

HENRY WYSOR, Metallurgical Editor.

PUBLISHED MONTHLY BY

THE CHEMICAL ENGINEER PUBLISHING COMPANY

355 Dearborn Street, Chicago

Entered as Second Class Matter, Aug. 19, 1907, at the Post Office at Chicago, Illinois, March 3, 1879.

Subscription—United States, Cuba and Mexico — \$2.00
Extra postage to Canada 25c a year; to foreign countries 50c a year.

Remittances may be made by check, draft, or money order in favor of THE CHEMICAL ENGINEER PUBLISHING CO.

All matter connected with subscriptions or advertising should be sent to THE CHEMICAL ENGINEER PUBLISHING CO., 355 Dearborn street, Chicago. Anything intended for the Editorial Department should be sent directly to the Editor, Richard K. Meade, Nazareth, Pa.

NOTES AND COMMENTS.

A New Process for Nitric Acid From Air.

In the *Zeit. für angew. Chem.*, of May 7, 1909, appeared a description by Dr. F. Russ, of Vienna, of the process employed by the Salpetersäure-Industrie Gesellschaft, for the production of nitric acid from air.

The writer divides the practical process for the production of nitric acid from air into three classes: (1) Process making use of disrupted discharges (such as the Bradley and Lovejoy process). (2) Processes utilizing a moving arc. The motion may be produced either mechanically or by the aid of a magnetic field (such a process is that of Birkeland and Eyde). (3) Processes based on the use of stable arcs (such as the process of the Badische Anilin und Soda Fabrik).

The process of the Salpetersäure-Industrie Gesellschaft, described by Dr. Russ, is of the second class and the change in the position of the arc is produced by mechanical means. The process which was worked out by Dr. Pauling is now in use in the plant at Patsch, in Tyrol. The electrodes are stationary and horn shaped, diverging at their upper end. They are made of iron and last about 200 hours. The arc first forms at the lower end of the electrodes, where the gap between them is narrowest, and is driven upward along the diverging electrodes by a blast of air which is admitted from below under considerable velocity. In this manner a permanent arc about one meter in length is obtained, a new arc being formed at the lower end of the electrodes once in every half-cycle of the current and this takes the place of the arc which has been driven to the upper end of the electrodes and which there breaks down. The supply of air to the arc is pre-heated and another air blast introduced at a lower pressure effects the requisite chilling of the gases. In practice the process gives a 1½ per cent yield of nitric oxide. The plant at Patsch is run by water power obtained from the river Sill. There are 24 furnaces, every three of which are built together in one block. Each furnace has two arcs. One man attends to six furnaces and a mica window in the wall of the furnace allows him to observe the interior. The gases issue from the furnace at a temperature of

800° C. and their waste heat is utilized for concentrating the nitric acid and nitrite solutions obtained by the process. The plant manufactures 30 per cent, 40 per cent and 60 per cent nitric acid. The yield is about the same as that claimed by Birkeland and Eyde. A 4,000 volt current is used, which is obtained by stepping down from 10,000 volts. The capacity of the plant is 15,000 h. p. The Salpetersäure-Industrie Gesellschaft is erecting two more factories, one in Milan and the other in South France with a capacity of 10,000 h. p.

The Fixation of Atmospheric Nitrogen.

Of the one thousand and more papers read before the Seventh International Congress of Applied Chemistry, which met in London the latter part of May and the first of June, none excited more interest than three papers upon the fixation of atmospheric nitrogen. These were by Bernthsen, Caro and C. Weiss. No problem of applied chemistry at the present time is of more vital importance than that of the fixation of atmospheric nitrogen. The successful solution of the problem is not one from which only pecuniary reward will arise, it is one, the solution of which will make the chemists who have succeeded in working it out epoch makers. The vast importance and the actual need of the solution of this problem were shown by Prof. Bernthsen in his address. The absolute necessity of supplying combined nitrogen to the soil in some form or other is now recognized as the first principle of agricultural chemistry.

The two sources of combined nitrogen at the present time available are ammonia salts and saltpeter. Practically all of the ammonia salts are obtained as by-products from the manufacture of gas and coke. While it is true that the production of ammonia and its salts could be greatly increased by the proper system of recovering the by-products from coke, it is probable also that the quantity of nitrogen for agricultural purposes, even if this were done, would be far too small to supply the drain to which the soil is being continually subjected.

The second source of supply of nitrogen available for fertilizing purposes is Chile saltpeter, obtained from the nitrate beds of that country. Conservative estimates place the extinction of the Chile fields in not more than 42 years. Sir Wm. Crooks, in his treatise on the wheat problem, prophesied that the supply of saltpeter would be exhausted before many years had passed, and he declared the situation of far greater importance than the possibility of the exhaustion of the coal fields. Crooks declared that by the year 1935 there will be such a demand for wheat that even if all the ground now available be planted, the yield per acre must be increased from 12.7 to 20 bushels in order to supply it. To obtain this result, however, 12,000,000 tons of saltpeter will be required annually over and above the 1,750,000 now being used.

Prof. Bernthsen gave an interesting summary of what has been done towards the fixation of atmospheric ni-

trogen. The different methods employed for this purpose may be divided into three groups; first, direct formation of ammonia from nitrogen and hydrogen, both of which have to be isolated for this purpose; second, the nitrogen is first isolated then converted into metallic nitrides and cyanogen compounds, which in their turn must be subjected to chemical reaction for the production of ammonia; third, the direct oxidation of atmospheric nitrogen, without the isolation of the nitrogen, and the conversion thereof into nitrates, etc.

A large number of methods are available for the academic production of nitrogen from air, none of which are of commercial importance. In the Linde process air is liquified and the nitrogen and oxygen separated by fractional distillation. Hydrogen obtained as a by-product is then combined with the nitrogen. This method of making ammonia is, of course, very expensive.

A large number of methods are also available for the production of nitrogen compounds by the second method. Bunsen discovered one of the earliest of these and also that potassium cyanide occurs in blast furnace gases. He even went so far as to make experiments to determine if his process could be carried out on a large scale.

Perhaps the first of the practical processes was that of Frank and Caro, who found that when nitrogen reacted with either carbon and barium carbonate or with barium carbide alone, some barium cyanide was formed, but at the same time large quantities of another body were obtained containing smaller proportions of carbon. This body is barium cyanide. A company was formed and in practical work calcium carbide replaced the barium carbide. The product contained no calcium cyanide at all, but consisted chiefly of calcium cyanamide mixed with graphitic carbon. The preliminary production of calcium carbide was subsequently found to be unnecessary, since smaller results were obtained by starting direct with a mixture of lime and carbon. The product so obtained is now generally known by the name of "kalkstickstoff" or "lime-nitrogen." It was found that by the addition of calcium chloride the reaction could be carried out at a lower temperature.

This fertilizer, while of great value in some instances, has to be carefully used and is not adapted to general employment. The third method of bringing nitrogen into a state of combination, suitable for the use of man, has of late received considerable attention. The direct combination of nitrogen and oxygen can only be brought about by high temperature, but the same temperature which brings about the formation of nitric oxide also tends towards its decomposition. For every temperature there exists a definite state of equilibrium between the oxide of nitrogen formed and the unaltered mixture of nitrogen and oxygen, and the quantity of nitric oxide produced at any temperature

can not exceed that corresponding to the state of equilibrium for this temperature. Only at a temperature under $1,200^{\circ}\text{C}$. is nitric oxide stable against the action of heat, but at this temperature the amount formed is exceedingly small. Even at $1,500^{\circ}\text{C}$. only one-tenth of one percent of the nitrogen in the air is converted into nitric oxide, and a very much higher temperature is necessary to bring about a reasonable degree of oxidation.

Many methods have been proposed, and for that matter are still being proposed, in which air is raised to a sufficiently high temperature by the combustion of suitable materials. All these methods present two difficulties—that of obtaining a high temperature on the one hand and on the other of separating the small quantity of the oxide of nitrogen from the products of combination, particularly water. The only process of apparent value is that of Haber, in which carbon monoxide is burned with air under pressure and thus the formation of water is avoided. At the present time the most promising method and what seems to be the coming method for utilizing atmospheric nitrogen consists in the use of electricity. Cavendish as early as 1785 noted the production of nitric acid from the air by the use of an electric spark. A number of workers gave the matter consideration from a laboratory standpoint. The first attempt to employ the process on a large scale was made by Bradley and Lovejoy, at Niagara Falls, in 1902. The first practical success, however, along this line was obtained by Prof. Kristian Birkeland, in Christiania, who worked in co-operation with a Norwegian engineer, Samuel Eyde. A very important improvement over the Birkeland and Eyde process was made by Otto Schöher, a chemist of the Badische Anilin-u. Soda-Fabrik, in which magnets were done away with.

After the nitrogen has been converted into nitric oxide it must be brought into a marketable state, that is either in the form of nitric acid, nitrates or nitrites. As soon as the nitric acid gas is cooled to a point about 600°C . the nitric oxide begins to unite with the excess of oxygen, forming nitrogen tetroxide. The oxidation does not go past this stage of its own accord. The gas is then passed through an absorption tower down which water is trickled. During this passage through the tower two-thirds of the nitrogen is converted into nitric acid and the remaining nitric acid is used over again. The absorbing liquid is run down the tower several times, becoming richer in nitric acid each time. On neutralizing this with soda, sodium nitrate is formed and can be crystallized out of the solution. For practical purposes, however, limestone is employed instead of caustic soda and calcium nitrate is obtained. This latter is as valuable as sodium nitrate for fertilizing purposes.

The production of nitric acid is an industrial problem of some magnitude, although it sinks into insignificance besides the fixation of nitrogen for agricultural purposes. If it is desired to obtain a marketable

nitric acid, the 40 per cent liquid from the tower can be concentrated, usually by means of sulphuric acid.

At the present time a large amount of chemical and engineering skill is being devoted to the solution of the problem of the manufacture of nitrogen compounds from the air. Nitric acid is one of the oldest known acids and was described by Geber, an Alchemist of the 8th century, who prepared it by distilling potassium nitrate with copper sulphate and alum, while the process making use of nitrates and sulphuric acid, at the present time employed for the manufacture of the acid, was discovered by Gauber in the 16th century. Nitric acid was an article of commerce in England as early as 1771 and was manufactured in this country as early as 1834. When we consider that the first attempts to manufacture the acid commercially by the electric current were made in 1902 and compare the progress made in the last 6 years with that made in the last 3 centuries, we have reason to believe that the solution of the problem of the economic production of nitric acid and nitrates from the air both for industrial and agricultural purposes is very near solution.

CHEMICAL SOCIETIES

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—Samuel P. Sadtler, Pres.; John C. Olson, Sec'y, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN CHEMICAL SOCIETY.—W. R. Whitney, Pres.; Charles L. Parsons, Sec'y, Durham, N. H.

SOCIETY OF CHEMICAL INDUSTRY, NEW YORK SECTION.—Maximilian Toch, Pres.; H. Schweitzer, Sec'y, 128 Duane St., N. Y. City. NEW ENGLAND SECTION.—F. E. Atteaux, Pres.; W. H. Walker, Sec'y, Box 1189, Boston, Mass.

WESTERN ASSOCIATION OF TECHNICAL CHEMISTS AND METALLURGISTS.—W. D. Engle, Pres.; H. C. Parmelee, Sec'y, P. O. Box 1421, Denver, Colo.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Charles B. Dudley, Pres.; Edgar Marburg, Sec'y, Univ. of Penn'a, Philadelphia, Pa.

AMERICAN ELECTROCHEMICAL SOCIETY.—E. G. Acheson, Pres.; J. W. Richards, Sec'y, Bethlehem, Pa.

AMERICAN LEATHER CHEMISTS' ASSOCIATION.—H. T. Wilson, Pres.; H. C. Reed, Sec'y, Stamford, Conn.

CHEMICAL SOCIETIES.

The First Semi-Annual Meeting of the American Institute of Chemical Engineers.

The first semi-annual meeting of The American Institute of Chemical Engineers was held on June 24, 25, and 26, 1909, at the Polytechnic Institute, Brooklyn, N. Y.

The meeting proved a very interesting and profitable one so far as the papers and excursions were concerned, the only drawback being the almost intolerable weather. The attendance was quite large for such a young society; about 85 chemists being present. The entire program, as planned, was carried out.

The meeting opened with an address of welcome from Comptroller Herman A. Metz, of the city of

New York. Mr. Metz is himself a prominent chemist, and hence was a very fitting representative of the city upon such an occasion. Mr. Metz's remarks were as follows:

"Mr. President, Gentlemen: I was asked to extend to you a welcome to New York. I know of only one hotter place than this, and I am glad that I am in New York, hot as it is, and I hope that you will feel the same before you get through.

"It is a great satisfaction to have you here—for such societies as yours to come together here for conventions and other purposes. I regret that from a business point of view we have not more to offer in the way of locations for plants. The policy of the city seems to have been to drive them out and they have gone to sister cities. I think you will find that our natural opportunities are such that we ought to have in certain sections of this city large manufacturing establishments. The conveniences offered to a manufacturing establishment in being located in a metropolitan district is apparent; help can be more readily obtained here than in rural districts—but you probably know more about your own business than I do (although I am continually reminded that other people know more about my business than I do myself). I wish to extend to you a welcome to New York—to our plants and to our city. It is usual for whoever takes a stranger to show him the town to say, 'You probably know more about it than I do.' You will find much to interest you here in this the grandest city on the face of the earth, and in Brooklyn, one of its best boroughs (although it would not appear so from what we read in the newspapers). I hope that you will enjoy your stay here, and that your discussions will be of great value, as an exchange of opinions and experiences must be at all times, and I trust you will find that you have made no mistake in coming to this town."

Mr. Metz was followed by Prof. Irving W. Fay of the Polytechnic Institute, who bespoke a welcome on behalf of the Polytechnic Institute. Prof. Fay's remarks were as follows:

"Mr. President and Members of the Institute of Chemical Engineers: The Polytechnic Institute is glad to welcome you, and to put its hall and building at your disposal during this session. The Institute has attempted, and it has, I believe, succeeded, in graduating men who shall have a good conception of the professional career which is before them. As it is an honest one and a serious one, there must be a standard set, and met, and if I understand the *raison d'être* of your Institute, it is the elevation of a higher standard among chemists and chemical engineers in this country. I do not think it has come a moment too soon. The Institute was formed immediately succeeding a period of panic—a good time for its formation. Business is now on the upward curve; better times are ahead, and a demand for more and higher class men. The need of the country in this respect is ap-

parent to anyone who knows the kind of men who have worked and done business under the name of chemist in the past. They remind me of an old lady, who was attending a meeting in the early history of the country when Unitarianism was first projected. Everyone was pouring anathemas upon Unitarianism because of the absence of the theories of damnation from its creed. After everyone had had their say, this dear old lady got up and approved of all that had been said and hoped that the doctrines of damnation would not be left out, because, she said, 'My damnation is very dear to me.' So I think some men have taken the name of chemist and held it dear out of veneration for the name. The influence of your Institute can do a great deal for the excellence, skill and power of the chemical engineer in this country. It has come not a moment too soon. I care not how great a panic there may be in England about building Dreadnoughts to fight Germany, the outcome of the struggles to be fought in the future will depend first on the natural richness of the country in which the people live, and after that it will depend upon the endowment of brains, and the training, with which the people are equipped. Your Institute has the high privilege of setting the standard, so that all men shall know the standard and when it is met. Every science must be standardized, and every standard must be high, and then comes progress, and the fruits cannot be located in any Institute; they will go to the humblest laborer who has a hand in producing anything that is produced in a better way because of it. I welcome you to the Polytechnic Institute, and extend to you the invitation to visit its laboratories."

President Sadtler then appropriately thanked the gentlemen who had welcomed the Institute as follows:

"On behalf of the visiting members of the Institute. I wish to thank very much the gentlemen who have welcomed us, and to say that we appreciate their welcome. This idea of coming to Brooklyn is a welcome change from attending, as we have done formerly, the various meetings in New York. The idea of having a meeting over here was a very agreeable surprise to me, and is, undoubtedly, a great pleasure to all of us. My earliest impressions of Brooklyn were in connection with a visit to the chemical works of Dr. Squibb, and therefore in connection with the chemical industry. I have no doubt that we shall learn very much in the course of the inspection of many of these industries of Brooklyn and New York. There is hardly a section of this great district, but what is important from a chemical standpoint. We have before us a very modest program, and ours is a very modest and young society. We have had to stand a little bit of ridicule because we are such a small society in comparison with the great organizations, but we do not propose to be a society that is starting in with a view to building up numbers—we are not following the same lines as some of the big societies. I think you will probably find that there is room for this kind of a society. Most of us

who belong to this organization belong also to other societies. Over and above that I think it will be evident after another meeting or two that there is room for a society of chemical engineers to come together to discuss the problem of applied chemistry, make acquaintance, and visit works in which the applications of chemistry are being carried out. We shall learn more in that way than in a year of reading about that kind of thing. I hope that our expectations will be realized in the papers of to-day and the excursions of the next few days. I will not take more of your time. First of all we have Secretary Olsen's announcements, and then we will go on with the program."

Secretary Olsen then outlined the plans for the entertainment of the members during the meeting and gave instructions as to how to reach the various places to be visited. The first paper of the morning was read by Prof. Wm. D. Ennis, Professor of Mechanical Engineering, Brooklyn Polytechnic Institute, on "The Efficiency Limits in the Power Gas Producer." Prof. Ennis said that the difficulty of separately and accurately determining the efficiency of a gas producer suggests a computation of its efficiency limits. When pure carbon is converted into carbon monoxide, 30.69% of its potential heating value is transformed into temperature and becomes unavailable for use in the gas engine. By using a certain proportion of steam mixed with the air supplied for gasification the temperature heat may be partially employed in decomposing the steam. The hydrogen then carries this temperature heat to the engine as available heat of combustion. With sufficient steam supplied the temperature elevation might be eliminated, and the efficiency would be 100%. Steam will not decompose readily at temperatures below 1740° F., however, and the proportion of steam must be limited to that at which this temperature is attained. The efficiency is then, theoretically, 83%.

A corresponding result follows the introduction to the producer ash pit of a portion of the waste gases discharged in the engine exhaust. The carbon dioxide then decomposes, and the heat absorbed is carried back to the engine. At the limiting temperature mentioned, the efficiency is 78½%. Modifying these results to include practical losses by radiation, fuel in ash, etc., variable specific heats of the gases, the presence of hydrocarbons in the fuel, the rise of surplus oxygen in the engine and in the producer, the initial temperature of the steam or waste gas and the formation of carbon dioxide, the maximum possible efficiency, with steam, appears to be less than 80%, and with waste gas slightly less still. Actual analyses of gases produced by the two methods check the computations to some extent. The conclusion is drawn that the temperature of the gas is the best crude indication of efficiency of operation.

The paper was discussed by Messrs. Behr, Ennis, Booth, Olsen, Grosvenor, Richards and Sadtler.

The next paper on the program was that of Dr. O.

K. Zwingerberger, on "The Utilization of Low Grade Fuels."

This paper gives the results of the experiments of the United States Fuel Testing Plants on the utilization of lignite and peat as fuel. Also the results of experiments carried out in Europe on the use of these fuels. The author describes the by-products produced by distillation, and their relation to the utilization of these low grade fuels. He showed that up to the present time the low cost of coal and oil did not permit the utilization of low-grade fuels. He showed that for some states, such as Texas, Dakota, Minnesota, etc., the utilization of such fuels is very important, and that by the use of special gas producers and the utilization of by-products such fuels are far more economical than anthracite or the best coke. By the combination of gas producer and a coking chamber an increase of 20% in heating value and a much larger output of gas can be obtained with these low-grade fuels. The paper is a very important contribution to the literature of the utilization of lignite or peat.

A discussion of this paper was deferred until the afternoon session. A business meeting of the members was then called.

Dr. Sadtler then announced the death of Dr. H. A. Hunnicke, of St. Louis, one of the vice-presidents of the Institute and read an obituary notice prepared by Dr. Frerichs.

The report of the membership committee was next read. This showed that the membership of the Institute at the present time is over 100.

A design for a button had also been ordered made and the matter of an engrossed form of certificate of membership had also been considered but no action had been taken. The committee recommended that members of the Institute should be more active in inviting chemists who are qualified to apply for membership. The report of the membership committee was followed by the report of the publication committee. The meeting then adjourned until two o'clock.

Mr. Jerome Alexander opened the afternoon session with a description of the ultramicroscope. This description was illustrated by the apparatus itself and a number of applications. It proved a very interesting paper and was listened to very attentively by all present. Many applications of the instrument were shown and discussed. This paper was then followed by three papers: "Creosote Oil from Water Gas Tar," by President S. P. Sadtler; "Some Experiments on Case Hardening of Steel with Gases," by Dr. J. C. Olsen, and "The Centering of Great Industries in the New York Metropolitan District," by Dr. Chas. F. McKenna. These three papers will be published in full in future issues of THE CHEMICAL ENGINEER. It, therefore, is unnecessary at this time to give an abstract of these papers. They were discussed by Messrs. Booth, Schute, Langmuir and Peckham. Other papers read at this session but not discussed were on "An Automatic Acid Egg," by Richard K. Meade, and "Meth-

ods of Clay Control," by J. G. Dean. Both of these papers appear in full in the present issue.

It was decided to hold the next meeting of the society either in Philadelphia or St. Louis, in probably the latter city, the date to be between the 1st and the 15th of December.

In the evening a subscription dinner was held at the Brighton Beach Hotel, at which some 25 were present. President Sadtler acted as toastmaster and the following toasts were delivered. "The Significance of Membership," by Prof. Wm. P. Mason, of Troy; "A Word from Sister Societies," by Prof. Jos. W. Richards, of Bethlehem, Pa.; "Our Baby Member," by Stephen P. Sharpless. Dr. Chas. F. McKenna, first vice-president of the society, also made a few solicitous remarks.

The keynote of all these addresses was the function of the Institute. Prof. Richards emphasized the fact that the Institute comprises a group of men engaged in technical work and that the technical application of scientific theories should be the field for our activity. He said that he had no doubts whatever as to the future of this sturdy infant of the chemical profession. It was a natural growth and as such could not be suppressed.

Dr. Sharpless emphasized the function of the Institute in discouraging unprofessional conduct of one kind or another.

The excursions were attended by from 30 to 70 men and included visits to the Atlantic White Lead and Linseed Works, Brooklyn, where the members were shown the manufacture of white lead, linseed oil, lead pipe and sheet lead. The steam lighter, "Atlantic" of the National Lead Co. then conducted the members of the Institute and their guests up the Hudson River to Edgewater, where they were shown the plant of the Corn Products Refining Co. at this point. Here they were shown the manufacture of glucose, starch, and corn by-products. Later on in the afternoon the members visited the plant of the Warner Sugar Refining Co., also at Edgewater. The trip back to Brooklyn was made on the steam lighter "Atlantic," which was placed at the disposal of the guests through the courtesy of the National Lead Co.

On Saturday the members made an excursion to the Standard Oil Co.'s plant at Bay Way, N. J., and in the afternoon to the Astoria plant of the Consolidated Gas Company.

Fortieth General Meeting of the American Chemical Society.

The summer meeting of the American Chemical Society was held at Detroit, Mich., from June 29th to July 2, 1909.

The sessions were held in the Central High School, Detroit, and in the Barbour Gymnasium of the University of Michigan.

The papers read before the industrial section were as follows: "Limitations of Use of Starch as an Accelerator in the Fusion Method," by C. K. Francis; "The

Technical Determination of Caoutchouc in Guayule," by Chas. P. Fox; "Laboratory Reagents and C. P. Chemicals," by Clarence Riegel; "Standard Hydrometers," by Louis A. Fischer; "The Temperature Work of the Bureau of Standards," by C. W. Waidner; "On the Influence of the Temperature of Burning on the Rate of Hydration of Magnesium Oxide," by Edward DeMille Campbell; "The Electro-titrimer," by H. B. Bishop; "The Present Status of the Chemistry of India Rubber," by W. C. Geer; "Free Lime in Portland Cement—A Mill Study," Arthur G. Smith; "The Inspection of Material," by J. E. Moore; "Bag-House Treatment of Blast Furnaces and Roaster Gases," by W. C. Ebaugh; "Hygienic Significance of Sulphur in Illuminating Gas," by F. E. Gallagher; "The Destructive Distillation of Coals for Illuminating Gas," by Alfred H. White; "The Determination of Fat and Soap in Sewage Effluents," by L. P. Kimmitt; "Observations upon the Direct Determination of Carbon in Various Steels," by G. W. Sargent; "Determination of Nitrates in Portable Water," by Robert Spurr Weston; "The Ash of Coal and Its Relation to Actual or Unit Coal Values," by S. W. Parr and W. F. Wheeler; "The Analysis of Asphalt and Asphaltic Compounds," by S. W. Parr, Brainerd Meras and D. L. Weatherhead; "A Series of Parallel Determinations with the Mahler and Parr Calorimeters," by S. W. Parr and W. F. Wheeler; "Further Application of the Specific Gravity Method for Determining Fat," by Chas. H. Herty and E. J. Newell; "Some New Extractives for Use in Determining Fats," by Chas. H. Herty; "Some Technical Applications of Titanium," by Isador Ladoff; "The New Brady Gas Apparatus," by William Brady; "A New Oil Gas Producer," by A. B. Davis; "Manganese in Steel—a Note," by L. Auchy; "The Analysis of Lead Arsenate for Water Soluble Impurities," by Roger C. Griffin; "The Bouquet of Wine and Beer," by N. H. Claussen; "The Importance of Pedigree Cultures of Barley for Brewing Purposes," by A. Nilsson; "The Decomposition of Calcium Carbonate by Steam," by Warren K. Lewis; "The Structure of Tin Plate as Determined by Its Method of Manufacture," by Wm. H. Walker and Warren K. Lewis; "Paint and Varnish Coatings as Accelerators in the Corrosion of Metals," by Wm. H. Walker and Warren K. Lewis; "Convenient Illuminator for the Microscopic Examination of Opaque Objects," by Wirt Tassin; "A Recent Metallurgical Product—Copper Clad Steel," by Wirt Tassin; "A Simplified Combustion Crucible," by P. W. Shimer; "Note on a Convenient Condenser for Extractions," by David Bloom; "Barium and Sulphur in Fluorspar," by H. G. Martin; "Cyanidation of Silver Minerals," by Theo. P. Holt; "The Preparation of Sodium Oxalate for Use in Standardizing," by John T. Baker; "Commercial Aspects of Peat as a Source of Chemical Products," by Chas. A. Davis; "Estimation of Pyridine in Aqueous Ammonia," by A. C. Houghton; "Studies in the Solubility of Portland

Cement," by G. G. Wheat; "The Twitchell Process of Glycerine Recovery as Compared with the Ordinary Soap Kettle Saponification," by O. T. Joslin.

On Tuesday evening a complimentary smoker was tendered the visiting chemists by the society of Detroit chemists at Harmonic Hall.

On Wednesday afternoon the society was entertained by Parke, Davis & Co. This entertainment consisted of a luncheon, inspection of their laboratories and a moonlight ride on the river.

On Thursday the society visited the University of Michigan, and that night a subscription dinner was held at Hotel Pontchartrain.

A large number of plants were open to visitation and Friday afternoon was left open for this purpose. The meeting was a successful one and was largely attended.

American Society for Testing Materials.

The twelfth annual meeting of the American Society for Testing Materials was held in Atlantic City, N. J., June 29 to July 3, 1909. The hotel headquarters were at the Hotel Traymore, and all sessions were held in the parlor of this hotel.

Wednesday afternoon was devoted entirely to recreation, of which Atlantic City affords a great diversity.

On Thursday evening an informal dinner was held, and on Friday evening an engineering smoker.

A great many of the papers read at the meeting were of engineering interest only. Those papers likely to prove of interest to chemical engineers are as follows:

"The Desirability of Standardizing the Testing of Insulating and Other Materials," by C. E. Skinner; "Report of Committee W on Standard Specifications for Hard-Drawn Copper Wire," by J. E. Capp; "Report of Committee O on Standard Specification for Coal," by J. A. Holmes; "Fuel Investigations, U. S. Geological Survey—Progress During the Year Ending June 30, 1909," by J. A. Holmes; "The Effect of the Various Constituents of Coal on the Efficiency and Capacity of Boiler Furnaces," by D. T. Randall and Perry Barker; "Annual Address by the President—Engineering Responsibility," "The Closing Up of Blow Holes in Steel Ingots," by H. W. Howe; "Further Investigations of Broken Steel Rails," by Henry Fay and R. W. G. Wint; "An Investigation of a Defective Open-Hearth Steel Rail," by Robert Job; "The Testing of Galvanized and Other Zinc-Coated Iron," by W. H. Walker; "Notes on Corrosion Tests of Iron and Steel," by R. B. Carnahan, Jr.; "Paints for Concrete—Their Need and Requirements," by G. D. White; "Disintegration of Fresh Cement Floor Surfaces by the Action of Smoke Gases at Low Temperatures," by A. H. White; "The Effect of Free Carbon in Tars from the Standpoint of Road Treatment," by Prevost Hubbard; "Methods for the Examination of Bituminous Materials in Use in Highway Construction," by Clifford Richardson and C. N. Forrest; "Bi-

tuminous Materials for Use in and on Road Surfaces, and Means of Determining Their Character," by Clifford Richardson; "Viscometer for Heavy Road Oils," by A. W. Dow; "Improved Instruments for the Physical Testing of Bituminous Materials," by Herbert Abraham; "A Machine for Testing the Ductivity of Bituminous Paving Cements," by F. P. Smith; "Notes on Testing Turbine Oil," by Robert Job; "A Further Development of the Penetrometer as Used in the Determination of the Consistency of Semi-Solid Bitumens," by C. N. Forrest; "Conditions Affecting the Determination of Carbenes in Bitumens of Carbon Tetrachloride," by C. N. Forrest and D. B. W. Alexander.

CORRESPONDENCE.

Editor of The Chemical Engineer.

Sir: In a very important article in the May number of *Journal Am. Chem. Soc.* by Professor H. G. Parker, the separation of precipitates from liquids by whirling in the centrifuge and pouring off the liquid, is described.

I wish here to bear testimony to the great value and applicability of Professor Parker's idea in the determination of phosphorous in steel, where I have used it for the last seven years (*Iron Age*, and *Journal Am. Chem. Soc.*, 25, 7, Note). Wide 7-inch test tubes holding 115 to 120 cc. liquid are used in an *Einer & Amend* "Universal" centrifuge, but provided with 5 special sized holders. Immediately after whirling, the yellow precipitate adheres so tenaciously to the bottom of the tube that the liquid may be poured and drained off as carelessly and confidently as though the tube contained nothing else but the liquid desired to be got rid of. The tube is then nearly filled with water, stoppered, inverted repeatedly to mix contents, and again whirled, and liquid poured and drained away. Then titration with standard caustic soda. As the yellow precipitate is undiluted, the standard soda acts so quickly and energetically that no excess beyond a drop or two is needed, and standard acid to titrate back is therefore unnecessary. Or, if it is desired to weigh the yellow precipitate, it is dried in the tube, and the tube then stoppered and weighed. My dismay would be great if for any reason I had to go back to filtering the phospho-molybdate. I have often thought of applying this scheme to other precipitates, but have been deterred by the fact that the bulk of the liquid usually exceeds 100 cc. Stupidly enough Professor Parker's plan of whirling in successive portions never occurred to me. Still, I am somewhat doubtful whether in such cases the centrifuge is a very great advantage, and moreover feel some doubt as to whether all precipitates stick to the bottom of the tube, so well as the phospho-molybdate does. Since reading Professor Parker's article, I have tried silicon in steel, and a small magnesium phosphate precipitate with poor success in both cases,

although in the former case, perhaps due to the floatant carbon.

In Drown's method where the silica is not contaminated with carbon, doubtless there would be no difficulty, and if so, the method would be a tremendous advantage in steel works' laboratories. But clever and ingenious as is Professor Parker's scheme of attaching a platinum crucible to the end of a glass tube, I would for my part nevertheless prefer the wide 7-inch test tubes, for the reason that in the former plan a ridge is formed inside at the junction of crucible to tube which prevents all the liquid from being drained off. In the latter plant the liquid used in washing out the precipitate into a crucible could be got rid of either by evaporation, or by whirling the crucible and pouring off the liquid.

GEORGE AUCHY.

BOOK REVIEWS.

A HANDBOOK FOR CEMENT WORKS CHEMISTS. By Frank B. Gatehouse, formerly chemist at the New Dartford Cement Works. 8 vo. Cloth. Illustrated. viii x 14.1. Price \$2.00. London, Charles Griffin & Co., Ltd.; Philadelphia, J. B. Lippincott Co., 1908.

This little manual consists of a collection of schemes for the analysis of those materials which find their way into the laboratory of a Portland cement plant. It is not confined solely to methods of analysis for raw materials and Portland cement, but also contains schemes for the analysis for coal, lubricating oil, boiler water and kiln gases. What perhaps will be considered as an omission, however, is the failure of the book to give methods for the physical testing of Portland cement.

The hand-book is divided into five chapters, the first of which is an introduction, and contains an appendix, consisting of tables and data of use to the cement works chemist. Chapter II is devoted to methods for the analysis of the raw materials. Chapter III is on proportioning of the raw materials, and includes the methods of checking the composition and of calculating the proportions of the various raw materials in the mix. It is interesting to note that this is done in England chiefly, by the use of the calcimeter, a number of improved forms of which are described. The acid and alkali method used largely for this purpose in this country, is taken from Meade's "Portland Cement," which would indicate that this way of checking the composition is not used abroad at all, while in this country, to the contrary, it is used almost universally. Chapter IV gives schemes for the analysis of lubricants, fuels and kiln gases, while Chapter V is on the analysis of cement.

The analytical schemes, in the main, are satisfactorily, although briefly, described. What would possibly puzzle American chemists, is the use by the author of Reddrop's system for expressing the strength of solutions used for reagents.

THE CHEMISTRY AND LITERATURE OF BERYLLIUM. Charles Lathrop Parsons, Professor of Inorganic Chemistry in New Hampshire College. 8vo. 180 pages. Price, \$2. Easton, Pa., The Chemical Publishing Co.

The author says, "This book was written with the main object in view of saving preliminary study and labor to future investigators of beryllium and to point out some of the peculiarities of this interesting element which are apt to lead the novice toward erroneous conclusions." Careful examination shows that this object has been well carried out.

The book is divided into two parts. Part I, pages 1 to 71, contains six chapters, Introduction, Metallic Beryllium, Normal Components of Beryllium, Acid Salts of Beryllium, Double Salts of Beryllium and Basic Compounds of Beryllium. Part II, pages 72 to 168, consists of a very valuable and complete bibliography. Concise extracts are given of all original articles as well as references to abstracts to such papers.

The book is a valuable one and is indispensable to anyone doing work on this element or its compounds.

J. H. DE LONG.

INDUSTRIAL AND PLANT NEWS.

Acid Phosphate. The Southern Refining Co., Athens, Ga., will rebuild its cotton-oil refinery. It will erect 400 x 100 ft. main buildings, and also install fertilizer machinery and electric motors to manufacture acid phosphate. Daily capacity will be 200 tons.

Alloys. The Syracuse Aluminum & Bronze Co., Syracuse, N. Y., is having plans prepared for a factory, which they will erect on Tracy St., at a cost of \$50,000.

Beer. The Geneva Brewing Co., Geneva, N. Y., is reported incorporated, with a capital of \$50,000, by Alex. M. Curtiss, W. A. Cornell and others, to operate a plant at Geneva.

Coke. The Dominion Iron & Steel Co., Sidney, N. S., it is reported, intends making extensive improvements in its plant, which will include a new battery of coke ovens.

Cottonseed Oil. A million dollar company has been organized under the laws of Arizona for the purpose of establishing and operating a fertilizer factory and cottonseed oil mill at Jackson, Ala. The company is capitalized at \$1,000,000 divided into 1,000,000 shares at \$1.00 each. J. B. Savage, Arizona, is president; Rudolph Dolive, vice-president; Benjamin F. Whisenhunt, secretary; J. S. Whisenhunt, treasurer. The name of the company will be the Clarke County Fertilizer and Oil Co.

Fertilizers. The Morris Fertilizer Co., 718 Empire Bldg., Atlanta, Ga., has awarded contract to D. J. Rose & Co., Rocky Mount, N. C., for the erection of fertilizer factory buildings. Peter S. Gilchrist, Charlotte, N. C., is constructing engineer. The plant is to be in operation about October 1; J. W. Robinson is manager.

Fertilizers. The Roberts Cottonseed Oil Co., Houston, Tex., have announced that they will shortly erect a fertilizer plant near Houston, Texas. The plans and specifications for the plant have been made. The fertilizer plant will work directly in connection with the oil mill and will turn out various kinds of fertilizers. The erection of the fertilizer plant will commence within the next few weeks, the machinery and materials being already on the ground. An endeavor will be made to get the plant

in readiness for the fall trade. It will have a capacity of 40 tons per day, which will consist mostly of cottonseed meal fertilizer.

Fertilizers. The Southern Refining Co., Athens, Ga., has closed a contract to purchase 50 acres of land near the city for the purpose of establishing thereon a large fertilizer factory. The new plant will manufacture acid phosphate, having a capacity of 200 tons per day, and in addition will manufacture other fertilizers. The plan will use sulphuric acid from the Ducktown plant of the Tennessee Copper Co. Work on this new plant will begin within the next few days, and will be finished before the opening of the fall season.

Lime. The Blair Limestone Co., Martinsburg, W. Va., has incorporated and begun the erection of its proposed plant which will have 32 limekilns, located two miles east of Martinsburg on the Baltimore & Ohio Railroad. The concern will also supply fluxing stone to Jones & Laughlin Steel Co., Pittsburg, Pa., for its steel plant. The lime plant is reported to cost \$300,000 when completed.

Oil. Important improvements will be undertaken by the Texas City Refining Co., of Texas City, Tex. The company has increased its capital stock from \$150,000 to \$300,000, and will increase its capacity from 2,000 to 4,000 barrels of oil daily, establish a cooerage plant, build 26 tanks and add considerable new equipment, to include cars, motors, centrifugal pumps, etc. The company also plans further improvements during the next two years, providing additional wharfage space, a system of warehouses, a grain elevator and improvements to its townsite, including water-works, graded streets, sewerage system, etc. Unconfirmed reports state that the future contemplated improvements will cost \$2,000,000. E. B. Gray of Texas City is the company's engineer in charge.

Sheet Steel. The Sharon Steel Hoop Co., Sharon, Pa., is preparing plans for a four-mill sheet plant here to cost about \$175,000.

Steel Products. The Independent Steel Co. of America has been incorporated with an authorized capital stock of \$2,000,000. The company is planning to build at Fairmont, W. Va., blast furnace, open-hearth steel furnace, rolling mill and wire mill.

Tin Plate. The McKeesport Tin Plate Co., McKeesport, Pa., will double the capacity of its plant by erecting an addition.

Portland Cement. The Inland Portland Cement Co. has been organized by H. C. Trexler and E. M. Young, of Allentown, Pa., with a capital of \$1,000,000, for the purpose of building a plant at Meraline, near Spokane, Wash., to have a capacity of 5,000 bbls. per day.

Portland Cement. The Tidewater Portland Cement Co., 115 Broadway, N. Y., is being organized to build at Union Bridge, Md., a cement plant which is designed to have an ultimate annual output of 1,000,000 barrels of Portland cement. The company will also manufacture white Portland cement, and will include kilns for burning builders' white lime and a plant for manufacturing hydrated lime, this latter to have an annual output of 25,000 tons, or 200,000 barrels. The company has been incorporated with a capital stock of \$4,000,000 and a bond issue of \$1,750,000. Hon. John K. Tener, M. C., is president. Richard K. Meade of Nazareth, Pa., is the company's consulting engineer, and William Bullock Clarke of the Johns Hopkins University, Baltimore, is its consulting geologist. Extensive deposits of limestone and shale have been purchased at Union Bridge, on the Western Maryland Railroad, 45 miles from Baltimore.

Tungsten. Operations on the Melvin group of tungsten claims at Round Mountain, Nevada, aggregate a total of 850 feet of work. The three tunnel dumps have several thousand tons of ore which will average \$25. The glory

hole method will be used in handling the ore, chuting down into the tunnel, where a grizzly will be used to good advantage in preparing the rock for use at the mill that is now a certainty. The style of rollers for the mill have been decided on and are now being manufactured. Manager Gohlin is also in communication with machinery manufacturers in the East arranging for a new and improved style of separator, and when the details of that are settled the plans for the mill will soon be under way and Round Mountain will soon be known as a producer of tungstic acid and have the honor of possessing the second mill in the United States for the production and treatment of that useful metal. The only mill now refining tungsten ores is situated at Boulder, Colo. Plans are also under way for building a mill at Spokane, Wash., to treat the tungsten ores produced at Murray, Idaho, and Deer Park, Wash.

RECENT INVENTIONS.

The following recent inventions relating to chemical and metallurgical patents have been specially reported by C. L. Parker, 908 G Street, N. W., Washington, D. C., solicitor of patents and patent causes.

918,612. Process of *Sepdrating Liquid From Solid Fatty Acids*. Ernst Twitchell, Wyoming, Ohio. April 20, 1909.

The process consists in separating intermixed solid and liquid fatty acids, from one another, which consists in dissolving in the liquid fatty acid a relatively small per cent of a sulpho-fatty acid, washing out with water the liquid fatty acid from the solid and decanting the liquid oil from the wash water.

918,647. *Treating Anode Slime* From the Electrolytic Refining of Lead. Anson G. Betts, Troy, N. Y. April 20, 1909.

The process consists in treating anode slime from the electrolytic refining of lead by dissolving metal therefrom by treatment with a solution containing fluorine, and with an oxidizing agent, of which the products of reduction by the slime are soluble in the solution, the said solution also containing a strong acid forming a soluble lead salt; and removing metal of the slime from the resulting solution.

918,648. Process of *Smelting Zinc Ores*. Anson G. Betts, Troy, N. Y. April 20, 1909.

The process consists in treating zinc ore by mixing the ore with a reducing agent unoxidizable by air below a temperature of 800°C., heating the mixed ore and reducing agent by the heat of a combustion process and reducing the ore by the action of said reduction agent at a higher temperature.

918,925. Process of *Treating Starch*. Frederick Supf, New York, N. Y. April 20, 1909.

The process consists in treating by weight—100 parts of pulverized, dry potato starch with 80 parts of a 50% solution of ammonium sulpho-cyanate in water to which have been added 40 parts of alcohol.

918,950. Process of *Reducing Metal*. Henry S. Blackmore, Mt. Vernon, N. Y. April 20, 1909.

The process consists in exposing a substance containing metal to electrolysis, while employing an electrode containing a metal acetylid decomposable by an ingredient of the substance employed and capable of liberating metal therefrom.

919,031. Process for *Rendering Material of Any Kind Proof Against the Action of Moisture and of Chemical Agents*. Abraham Kronstein, Karlsruhe, Germany. April 20, 1909.

The process consists in impregnating said material with liquid wood oil (tung oil) and subjecting the material thus containing the oil to a temperature sufficient to convert the oil into its solid polymeric form.

919,049. Process of *Purifying Potassium Bitartrate*. Manuel F. Martinez, Jerez de la Frontera, Spain.

The process consists in treating crude tartar with a mineral acid in the cold state, filtering and decolorizing the resulting liquid, treating said liquid with an alkaline salt, precipitating the metallic compounds in the solution, filtering the solution, then adding a potash salt to the filtered solution to precipitate bitartrate of potassium.

918,628. Process and Apparatus for *Extracting Bitumen* from Bitumen-bearing Ore. George M. Willis, Chicago, Ill.

The process consists in extracting bitumen from bitumen-bearing ore by grinding the ore to a sand, heating the sand in water and causing agitation of the resulting floating mass to release the same, removing the precipitated sand, then causing the residue to flow in a thin stream, and heating it to drive the moisture therefrom.

918,908. Process of *Extracting Silver* from its Ores. James C. Pryor, North Bay, Ontario, Canada. April 20, 1909.

The method consists in eliminating the baser metals from an ore containing silver with baser metals, by first calcining the ore to oxidize the metals therein; then treating the oxidized ore with a suitable reagent to reduce the oxides so formed; then treating the mass with a solvent of the baser metals.

918,997. Process for *Producing From Straw, A Liquid Suitable for the Production of Alcohol*. William F. Giles, New York, N. Y. April 20, 1909.

The process consists in leaching out successively separate quantities of straw under pressure with the same quantity of boiling water, removing the concentrated liquid thus obtained, and acidulating the same whereby extracted substances are transformed into fermentable matter.

919,375. Method of *Recovering Zinc Compounds and Ammonia*. Ellas G. Pearlman and Martin M. Pearlman, Philadelphia, Pa. April 27, 1909.

The method consists in roasting or smelting sal-ammoniac-fluxes or skimmings, by-products of the galvanizing process, acting on the gases and fumes given off first with steam, then with an alkaline solution and finally treating the remaining gases with an acid solution.

919,410. Composition of Matter to be Used as an *Indelible Marking Agent*. Charles Wild, Jr., Valatie, N. Y. April 27, 1909.

The composition comprises printers' ink, a coloring substance and a basic substance with which the foregoing is melted and agitated.

919,434. Process of *Extracting Precious Metals from Their Ores*. William L. Imlay, Conestoga, Pa. April 27, 1909.

The process consists in pulverizing ores while they are subjected to a solution capable of dissolving the contained values, and alternately heating and cooling said ore and solution while being exposed to light and air, and under agitation.

919,560. *Sanitary Calcimine*. Carleton Ellis. Larchmont, N. Y. April 27, 1909.

The calcimine comprises a waste lime sludge, a disinfecting material and an organic binder.

919,663. Process for *Testing or Producing Ores*. Edwin P. Welch, Denver, Colo. April 27, 1909.

The process consists in mixing ore in a finely powdered form with material containing potassium chlorate, sodium peroxide and carbon containing material and igniting the mass.

919,709. Method and Apparatus for *Sorting Slimes in Ore Concentration*. James N. Flood, Denver, Colo. April 27, 1909.

The method consists in effecting a flow of an aqueous mixture of the particles to be separated and establishing an upraised wave on the surface of said mixture without obstructing the flow of the mixture below the normal level thereof.

919,759. *Solidified Alcohol and Process of Making the Same.* Victor Perelzveich and Gustav Rosenbusch, Zurich, Switzerland. April 27, 1909.

The solid alcohol is produced by mixing alcohol with tris-earin, sodium sebate, and tetra-nitrate of cellulose.

919,762. *Process of Producing Isoboryl Esters.* Curt Philipp, Dresden, Germany. April 27, 1909.

The process consists in heating pinone hydrochloride with fatty acids and with fatty acid salts of heavy metals.

919,839. *Process of Removing and Recovering Tin.* Julius Elkes, Mount Pleasant, Pa. April 27, 1909.

The process consists in converting the tin into a tin sulfide, then converting it into a tin dioxide, and then reducing the tin dioxide with a carbonaceous substance.

920,119. *Manufacture of Fuse.* Henry E. Ellsworth, Simsbury, Conn. May 4, 1909.

This method comprises the treating of strands of threads with a fire proofing solution, spinning the strands, and feeding a medium for conveying the fire into the strands as they are being spun.

920,224. *Process of Manufacturing Nitric Acid.* Friedrich S. Valentine, Leipzig-Plagwitz, Germany. May 4, 1909.

The process consists in creating an excess of pressure in a retort containing sodium nitrate and sulphuric acid by throttling the nitric acid gases passing from the retort, maintaining a partial vacuum in the condenser, and purifying the collecting condensate by forcing there through the following uncondensed nitric acid gases.

920,332. *Method of Manufacturing Sublimed White Lead* Louis S. Hughes, Joplin, Mo. May 4, 1909.

The process consists in treating ores or compounds containing lead sulphide for the production of sublimed white lead, containing a product consisting chiefly of lead sulphate, without the production of metal, slag, or other fused or liquid product, by finely dividing the ore or compound, mixing it with air, igniting the mixture of air and ore particles, maintaining its combustion at temperatures below those at which the ore particles will fuse, separating the unburned particles of ore from the gases and lead sulphate fume by subsidence and separating the lead sulphate from the gases.

920,391. *Process for Refining Metal.* James H. Reid, Newark, N. J. May 4, 1909.

The process consists in reducing and refining metal ore by first melting the ore, then mixing the same with carbon monoxide gas to produce a frothy mass of gas and ore, and then rotating said mass and exhausting the surface thereof.

920,560. *Manufacture of Iron or Steel by The Basic Bessemer Process.* Josy Flohr, Rodange, Luxemburg. May 4, 1909.

The process consists in blowing air through molten pig iron contained in a converter, until the carbon is wholly or almost wholly burned, and then introducing calcium hydrate briquets into the bath and again blowing in air until the refining operation is completed.

920,601. *Process of Making Metallic Sulphates.* Otto Meurer, Cologne, Germany. May 4, 1909.

The process consists in first heating the sulphides with alkali sulphide, then exposing the mass to air until self oxidation has proceeded only so far that the ferric oxide produced remains soluble in dilute acid, and finally lixiviating the mass.

920,610. *Process and Apparatus for Producing Oxides of Nitrogen by Means of a Rotary Flame.* Ignacy Moscicki, Freiburg, Switzerland. May 4, 1909.

The process consists in maintaining electrically a flame between the electrodes to increase the resistance and prevent short circuiting and introducing reaction gases to the influence of said flame.

920,638. *Process for Diminishing the Formation of Flaws or Blow-Holes when Casting Blocks and other Pieces.* Alfred von Paravicini, Hagen, Westphalia, Germany. May 4, 1909.

The method consists in putting on the feeding head a small quantity of a deflagrating mixture and in thereafter covering the surface of the feeding head with a bottom layer of solid incombustible material in a state of division which is substantially inert with relation to the metal to be cast and with a top layer of a combustible substance likewise in state of division.

920,828. *Process of Making a Cellulose Material.* Charles F. Cross and John F. Briggs, London, England. May 4, 1909.

The process consists in treating fibrous cellulose with an appropriate acetylating agent until there is an increase in its weight not exceeding 50 per cent. without appreciable alteration of the textile qualities of the fiber.

920,881. *Radium Compound and Process of Making Same.* Johannes Reitz, Schmargendorf, near Berlin, Germany. May 1, 1909.

This is a permanent radio-active crystalline product derived from a bromide of radium solution and anhydrous sodium carbonate which forms a white crystalline mass suitable for internal application for medical purposes and at the same time retains the radio-activity of the radium bromide therein and avoids its conversion into helium.

920,893. *Art of Extracting Aluminum and Other Metals.* Henry S. Blackmore, Mount Vernon, N. Y. May 4, 1909.

The process consists in fusing a substance containing the metal desired to be produced by the action of an alternating current disposed or applied therethrough, and liberating the desired metal therefrom by the action of a direct current.

921,000. *Manufacture of Water, Acid, and Alkali-Proof Articles.* Isaiah L. Roberts, Lockport, N. Y. May 11, 1909.

The method consists in treating articles composed of woody material to render the same water, acid and alkali-proof, by partially carbonizing the article in a heated bath of water-proofing and resistant material and permitting the material of the bath to permeate the article.

921,148. *Process for Regenerating Rubber Waste of All Kinds.* Julius H. L. Neilson, Han-over-Linden, Germany. May 11, 1909.

The process consists in dissolving the vulcanized rubber in the products of distillation of colophony of high boiling point and then precipitating the rubber from the solution by means of a ketone.

921,183. *Process of Reducing Ores.* Frank J. Tone, Niagara Falls, N. Y. May 11, 1909.

The method consists in electrically heating the ore and the reducing agent within the reduction zone of an electric arc, to a temperature sufficient to reduce the compound, removing the reduced product by gravity away from the reduction zone and electrically heating said products during such descent and removal, said heating being accomplished in a zone below and distinct from the reduction zone.

921,251. *Process of Extracting Essences and Tinctures from Vanilla-Beans.* Elton M. Howell, New York, N. Y. May 11, 1909.

In this method a mass of raw ground vanilla beans in a suitable closed vessel is subjected to the solvent action of dilute alcohol, consisting in maintaining a column of said solvent in contact with and above said beans, the diameter of said column bearing to its length the approximate ratio of two to seven, heating the lower portion of said column till the temperature of the top of the column of solvent approximates 100° F., then cooling the column of solvent and beans to that of the surrounding atmosphere, percolating the liquid portion through the ground mass and returning the percolate to the said mass to complete the extraction.

The Chemical Engineer

PUBLISHED BY

The Chemical Engineer Publishing Co., 355 Dearborn St., Chicago

Vol. X.

AUGUST, 1909.

No. 2.

THE CENTERING OF GREAT INDUSTRIES IN THE NEW YORK METROPOLITAN DISTRICT.*

By CHARLES F. McKENNA, PH.D.

*Consulting Chemical Engineer, 50 Church St., New
York City.*

If on a map of Greater New York and its environs we were to draw a line from the city of Yonkers on the Hudson in New York to the city of Paterson on the Passaic in New Jersey, and then extend it southerly to the city of Newark, to Elizabeth, to Perth Amboy, around Staten Island, thence to and around the easterly boundaries of the borough of Queens and The Bronx to the city of Yonkers again, we should have circumscribed a territory approximately 700 square miles in area, whose great natural and acquired advantages for the economical manufacture of the greatest variety of materials have brought about most happy and satisfactory results for commerce and technology.

In this territory will be found located the great sugar refineries of Yonkers, Edgewater, Jersey City, Brooklyn and Greenpoint; the silk and woolen mills of Paterson, Passaic and Hoboken; the metal smelting works of Newark, Irvington, Perth Amboy, Cartaret, Staten Island, Bayonne and Laurel Hill; the corn works of Shadyside; the chemical works of Lodi, Shadyside, Newark, Perth Amboy, Bayonne, Staten Island, New York City, Bushwick and Greenpoint; the jute mills and fiber works of Brooklyn; the linen and cotton thread works of Paterson and Newark; the lead and white lead works and linseed oil plants of Staten Island and Brooklyn; the paint and varnish works of Newark, Jersey City, Long Island City and Brooklyn; the lard refineries of Guttenberg, Jersey City and New York City; the cotton oil refineries of Guttenberg; the great soap works of Babbitt, New Jersey and New York and Jersey City and Staten Island; the glue and fertilizer industry of Newark and Barren Island, and lastly the great mineral oil refineries of Brooklyn, Edgewater, Bayonne, Bayway and Greenpoint.

It has not been my principal view to refer to the other very large manufacturing interests for which

the district is famous, such as the production of clothing and of the great variety of general articles of wood, leather, metal or whatsoever material; or to the manufactures solely intended for supplying utilities to the district, such as gas making; I mean rather to consider the great fundamental industries in which raw material is treated in a large way for the supply of the world's markets with staples. Those listed thus make a very impressive array. Some general figures about them make an astonishing showing.

Eighty per cent of the 6,000,000,000 pounds of refined sugar used in the United States is refined here; the concern which refines 80 per cent of the petroleum in the United States has here five of the largest of its twenty refineries, and another concern one refinery; the silk mills of the district, including throwing, weaving and dyeing works, are more than 60 per cent of all in the country, and produce more than \$60,000,000 worth of goods, and so on through most of the industries which seem almost peculiar to the district, so concentrated is the country's production therein.

The foreign commerce figures of this and certain other large ports are striking:

TOTAL IMPORTS, FISCAL YEAR 1907.

New York City.....	\$ 853,696,952
Boston	124,432,977
Philadelphia	79,869,942
Baltimore	37,774,395
San Francisco	54,094,570
New Orleans	46,046,772
All other points	238,505,907
	\$1,434,421,425

TOTAL EXPORTS, FISCAL YEAR 1907.

New York City.....	\$ 616,270,674
Galveston	236,277,727
New Orleans	169,897,311
Boston	99,820,742
Philadelphia	94,542,966
All other ports.....	636,908,614
	\$1,853,718,034

But the census figures for all manufacturing industries hereabouts also contain some statistical truths of importance.

*Read at the First Semi-Annual Meeting of the American Institute of Chemical Engineers, Brooklyn, N. Y., June 24, 1909.

INDUSTRIES OF METROPOLITAN DISTRICT—COMPARATIVE
RETURNS FOR 1900 AND 1905 FROM MUNICIPALITIES
WITH POPULATION EXCEEDING 8,000.

	Number of Establishments.		Aggregate Value of Products.	
	1900.	1905.	1900.	1905.
New York city....	12,243	20,839	\$1,172,870,261	\$1,526,523,006
Yonkers	107	105	17,303,620	33,518,088
	19,350	20,944	\$1,190,173,951	\$1,560,071,094
New York state....	35,957	37,194	\$1,891,830,872	\$2,488,345,579
Bayonne	63	58	38,601,129	60,633,761
Bloomfield	39	33	3,370,924	4,645,483
Elizabeth	141	124	22,861,375	20,300,801
Hackensack	21	23	782,232	1,488,358
Harrison	41	41	6,086,477	8,408,924
Hoboken	194	279	10,483,079	14,077,305
Jersey City.....	536	628	72,929,690	75,740,934
Kearney	16	11	1,607,002	4,427,904
Montclair	23	19	663,592	621,145
Newark	1,573	1,600	112,728,045	150,655,227
Orange	74	66	2,995,688	6,150,635
East Orange....	22	17	2,086,910	2,326,552
Passaic	70	95	12,804,805	22,782,725
Paterson	487	513	48,502,044	54,673,083
Perth Amboy....	47	53	14,061,072	34,800,402
Union	57	77	3,403,136	3,512,451
West Hoboken....	65	95	4,769,436	5,947,267
Metropolitan dist. in New Jersey..	3,469	3,732	358,736,936	479,592,957
New Jersey.....	6,415	7,010	553,005,684	774,369,025

SUMMARY.

	Establishments.		Aggregate Value of Products.	
	1900.	1905.	1900.	1905.
Metropolitan dist., New York.....	19,350	20,944	\$1,190,173,951	\$1,560,071,094
Metropolitan dist., New Jersey....	3,501	3,781	361,174,370	483,165,091
Metropolitan dist., total	22,851	24,725	\$1,551,348,321	\$2,043,236,185
Rest of U. S.	184,711	191,537	\$9,859,772,801	\$2,758,910,902
Total of U. S.	207,562	216,262	\$11,411,121,122	\$14,802,147,087

From the above table it will be seen that the states of New York and New Jersey, which contain about one-eighth of the population of the United States, produce within their bounds nearly a quarter of the aggregate national manufactures. Of the three and a quarter billions made in these two states, about two billions fall to the share of the Metropolitan District, or about one-seventh of the entire production of the United States, while its population may be estimated at about one-twelfth of the total. The importance of the district as a factor in our national industrial economy is thus amply illustrated. With its two billion annual product of varied manufactures, the Metropolitan District far outstrips the other general manufacturing cities in the country; Chicago being next in importance with one billion dollars; Philadelphia and Camden following with six hundred and twenty-five million, and Boston with the neighboring cities showing about three hundred and sixty millions.

The manufacturing capital in the whole of the United States was, in 1905, about thirteen billion dollars, or 86 per cent of the annual product. The proportion shown for the Metropolitan District was about 72 per cent of the annual product. Thus the Metropolitan District gets a larger return on capital invested than the rest of the country.

COST OF LABOR.

By the census figures the amount of wages paid in the entire country on the product of \$14,802,000,000 in 1905 was \$2,611,000,000, or about 18 per cent. A separate figure for the Metropolitan District was about 16 per cent. This again can be laid to high value of machine output.

The author concludes by expressing the belief that the territory thus described and recognized as the great Metropolitan District is destined to become the most interesting technological center in the world and the seat of the most varied and the largest establishments treating raw materials for the production of staples.

NATURAL CAUSES FOR GROWTH.

It is well for the citizens of the metropolis to understand why these industries have been attracted to it, how they can be held and encouraged to increase and how others can be induced to settle within the same area.

The location of great industries sometimes moves the world almost as much as political and great popular movements. The cotton of Manchester, the iron of Cleveland, the soda of Newcastle in resisting competition of place and of process, by being firmly rooted, have affected the destinies of England beyond estimation. The fight of Pittsburg against the Lake District, the South and the seaboard will result, though a strife among brothers, in the absolute domination of the United States in the iron and steel trade of the world; while the contest between the cotton mills of New England against the advancing front of the Southern mills has brought about in the former such attention to detail and in economy, and such application of higher technical skill trained in special schools for that very emergency that the result is the protection of enormous investments, the perfecting of products and a stop to the loss of trade.

In seeking for natural or historical reasons to explain the industrial development of this region, we find in the first place that while this fair section of our planet has both hills and plains, it is washed and serrated by a generous supply of waterways, that these in turn are deep and that they terminate in bays of large extent, discharging voluminously into the ocean.

A properly drawn map will also show a great network of rails approaching the center, running along the banks of these waterways, crossing them above, below, connecting and interconnecting. When to those natural advantages we add that of a commanding position as a port of entry, and one where articles of export can be most favorably taken on, we see that these are the overwhelming influences causing the growth. Civic pride directing the mighty forces to co-operate here has not at all been the agency for good that we might imagine—the great city has grown rather in spite of a deficiency of such pride. The historic significance of the early selection of this port for entry by the trans-oceanic vessel lines, the genius of De Witt Clinton, the parallel powers of Alexander

Hamilton, have frequently been recorded, but notwithstanding the existence of chambers of commerce, boards of trade and merchants' associations, few grand conceptions similar to Clinton's creation of the Erie Canal and Hamilton's foundation of a city on the Passaic and the utilization of the water power of that river, or similar to the introduction of the Croton water system into New York City in 1812 have been formed or brought about to completion.

Lack of perception between the states and amongst numerous municipalities that their interests were so intertwined as to be identical have hampered great undertakings leading to expansion of manufactures; and in many ways when these did not operate as inhibiting agents the evils of petty political maneuvering did.

The writer proposes to show that if the great Metropolitan District just described could be included in a commercial zone to be covered by treaty in which the community of interest would be thoroughly recognized, for the improvement of waterways, raising of flooded land areas, the erection of docks, increase of water supply, tapping and introduction from a distance large supplies of fuel, gas or electricity, protection of certain areas against land exploitation in order that housing may be sanitary, salubrious and secure for the laboring man; all of these could be brought about without waiting for the haphazard development that comes with the urgency of demand. An enlightened and broad minded consideration of the rights of the ten million dwellers to be in this territory ought now to be taken up by those highest in authority and most able to bring about the good.

Let us consider how these great works came to grow. Many of them, such as the sugar business and chemical works were in the very earliest history of the city used to meet the local demand of their vicinity. The first sugar refiners were the confectioners. The first lard refining was in the slaughter houses. The possibility of shipping by the Erie Canal and the bringing of hard coal by rail and water determined that the refineries, paint works and chemical works could increase, and the supplying of the outside world began. The greatest factor of influence besides those already mentioned was undoubtedly the draining of the Pennsylvania oil fields into this center by means of a pipe line 400 miles in length.

The offensive character of some of these businesses, and the necessity for securing large areas of cheaper land than city lots gradually caused the establishment of factories in the meadow lands of the surrounding river valleys, and in many cases the works that had removed to a desolate spot became the center and cause of a small city itself. Then improvements were made in processes which made even some of the most offensive innocuous and not in such wise undesirable.

SITES.

We find now the following situation as regards site and position. The Hudson River from Yonkers down

to and opposite Riverside Drive has been taken up for park or ornamental purposes, which will exclude factories in the future. The city generally has such extraordinary demand for its docks for steamship and general city purposes that very little manufacturing will in the future be done immediately on Manhattan Island's waterfront. Brooklyn, Astoria and a part of The Bronx shore will continue to attract manufacturers. South Brooklyn is particularly advantageously situated although the land areas are not so large. Staten Island, from the point of view of deep water frontage and large inland areas is an ideal situation and promises to continue the great growth which has been going on for a score of years. Perth Amboy, Bayonne, Elizabeth and Newark are rapidly assuming positions of importance in the establishment of large units of production of manufactures. Jersey City, Hoboken, Weehawken are old established sites improved nearly to their limits. Passaic and Paterson are desirable locations for manufacture of articles susceptible of carrying heavier charges for handling, and calling for a large force of contented skilled labor. The meadows skirting the shores of the Hackensack, Newark Bay and Passaic River have been left to the last, because we considered it one of the most important of the local areas, and the one which will call in the future for the application of the most far-sighted principles of development. These meadows extend from Elizabeth to Hackensack and are of the general width of four miles and are about eighteen miles in length. There is an area of 27,000 acres involved. There are twelve important lines of railway crossing them. The improvement by filling and utilizing as solid land areas this great and almost unused territory is a dream which has fascinated many engineers and economists, who see on the one side of it the great metropolitan city and on the other side other large cities growing towards one another until they appear to meet and form another unit which could almost be called a metropolis.

Admitting that one of the great reasons for the development of Manhattan Island was its beautiful situation, washed by swiftly flowing and broad streams on two sides, one finds in these other two rivers, the Hackensack and the Passaic, the promise of great advantage if only the low-lying bordering acres could be properly prepared for industry. Such an improvement was proposed in 1896 (Geological Survey of New Jersey, Report of State Geologist for 1896) by C. C. Vermeule, whose plans included a system of embankment and subsequent removal of the water by pumping. This has never been carried out on exactly the same plan as proposed by Vermeule, but to some extent certain portions of these meadows have been improved by depositing upon them river mud and sand dredged by hydraulic dredges. The result is that at present an area of several hundred acres has been prepared for use, none of which has yet, however, been improved by factory buildings.

The city of Newark interested itself in securing the deepening of the channel in Newark Bay to about the center line of the city. This improvement has just been consummated. The same city is also at work on a project of excavating further channels and a canal system bordered by bulkheads behind which the dredged material will be deposited, thus reclaiming an area of three or four thousand acres.

FUEL AND POWER.

The great element of advantage to New York in the past has been its proximity to the anthracite coal fields of eastern Pennsylvania. This valuable fuel was supplied in amounts of extraordinary tonnage, and at prices which for a great many years during the early development of manufactures was extremely low. The appearance of the specter of extinction of its valuable deposits has been one of the elements along with the high labor costs and high freight rates to bring about high prices for this coal delivered in New York City. The price has continued to increase till now steam sizes in large lots are from \$2.50 to \$3.00 per ton. Bituminous coal is coming more and more into use in the outlying parts of this district where smoke consuming may not be so strongly enforced. The prices of this coal are on a par with anthracite. Of both kinds of coal the factory demand on New York harbor points is about 2,500,000 gross tons annually.

With such fuel charges the cost of steam power would have risen to a damaging level were it not for a coincident improvement in boiler and steam engine practice. The need of large volumes of water for condensing has not been felt by any of the factories located on the tidal streams and bays. In the great railway power houses increased efficiency is being reported, and it seems as if extensive manufacturing establishments ought to acquire whatever of these advantages are not due to regularity of output and steadiness of load. The great losses from imperfect combustion and from unburned coal still continue to be viewed calmly by numbers of managers.

In the future new sources of power will probably be placed at their command, and inasmuch as the largest field for such power will be where manufactures are most concentrated, it is easy to see what could be promised for the district of New York and Newark and the meadows territory lying between. In the first place we could consider the advantages of power gas. If gas were manufactured for a market at 40 cents, the residuals being produced on a large scale the consumption for gas engines would warrant the establishment of such a works in a very large unit in the most desirable place in the center of the greatest consuming territory. With the improvements in gas engines, with direct connected electric generators, the installation of large units intended for the production of power by power-gas is very promising.

Another source of cheaper fuel and power might be sought for in the utilization of the culm banks of the

coal mines in the anthracite district, but whether this culm could be carried or floated to New York, or whether it should be gassified near the point of largest supply and the gas piped to New York, does not make such an important question, inasmuch as culm would appear to be an unreliable source and itself rising in value where it is produced.

The advance in producer-gas practice, so well known to you all, points the way clearly for economy to whose works managers who can use the product to most advantage; and the adoption of the producer principle to ordinary furnaces promises still further economy of fuel. Oil as fuel should continue to excite interest even at this point four and five hundred miles from the original source of supply of crude oil. The reason for this lies in the fact of an interesting change in the mineral oil industry coming about through the rapid introduction of power vehicles and power boats. The great demand for gasoline caused by these has brought about such changes in refining that a larger yield of fuel oil is now obtained than formerly. As a consequence its value is as low as 23½¢ per gallon. The Appalachian, the Lima and the mid-continental fields, with pipe lines to New York, and producing over 50,000,000 barrels of oil, from which 20 to 25 per cent of fuel oil can be obtained, certainly gives promise of a steadiness of supply, even if the demand should grow great.

The most fascinating promise of new power for this district comes from the hopes of the utilization of certain water powers. The nearest is the power of the Passaic River. It is proposed to establish reservoirs along this stream so that the present flow can be better regulated and power obtained over long intervals, but at its best the maximum of power obtainable from this stream is only 12,000 horsepower, and is already owned by the Society for the Establishment of Useful Manufactures founded by Alexander Hamilton and controlled by the East Jersey Water Company.

The next most valuable source is to be found in the Delaware River in New York state; the next after that the water powers of the upper Hudson River.

In an admirable report of the New York State Water Supply Commission on Water Storage and Power Developments, 1909, these are particularly well described.

In the case of the Delaware water power, the following appears in the special report of the engineer, in speaking of the improvement of the Delaware River between Cannonsville and Port Jervis, which could furnish 40,000 to 50,000 constant mechanical horsepower: "This 40,000 to 50,000 continuous hydraulic horsepower will generate, at 95 per cent efficiency of electrical machinery, from 28,500 to 36,600 kilowatts, which, distributed under a 50 per cent load factor, and 85 per cent efficiency in transformation and transmission, would deliver in ordinary working hours a maximum of 65,000 to 81,000 electrical horsepower at the consumer's end." He says: "There is at present no

nearby demand for anything like this enormous amount of power. The only adequate market from which returns might be expected is to be found in the thriving manufacturing cities of eastern New Jersey at an average distance of ninety miles. The industrial activity in many of the places within fifteen miles of Jersey City, together with the rapid growth in population, and the constant extension of electric railways throughout this district, hold out attractive possibilities for the sale of electric power."

But the most promising scheme is the development of the upper Hudson between Troy and Hadley, where horsepower is already developed, but where by systematic improvement 196,000 total horsepower could be developed, and as the distance from New York is not at all prohibitive for economical transmission it would seem as if yet it would materialize. A very powerful agency for bringing this about in the future will be the concurrent improvement in the hydrographic situation which goes with this power improvement, namely, the prevention of floods with all of their accumulated evils.

Given a supply of electrical horsepower in this Metropolitan District under consideration, we could easily see how manufacturing for export of every variety of substances which can now be made the product of the electrolytic vat or the electric furnace will bring still larger industrial interests. And this mode of application of the current is the most promising one for the justification of these distant hydroelectric plants; inasmuch as the demand at an electro-metallurgical works is not as exacting as that of an electric railway, because the volume of current demanded in the former permits of long-distance transmission with less line and transformation losses.

If the water powers of the Passaic, the Delaware and the Hudson were improved and utilized, thus in and near New York City the combined power supply and present manufacturing development of Niagara Falls, N. Y., and of Lowell, Lawrence and Holyoke, Mass., could be duplicated here and leave many thousands horsepower to spare. The politico-economic effect of such a concentration would be as interesting a study as that of its technological consequence.

WATER SUPPLY.

But a great want in the future will always be water supply. There are few subjects which give the technical factory manager operating here more concern than this. Shortage of supply, corrosion of boilers, incrustation, or large water bills—some or all of these things afflict all but the most favored.

The point of view of the governing authorities in considering water supply is always of course first the question of the securing of a potable supply. But the factory manager gives attention also to the questions of qualities for his purposes and of cost. A potable water supply would not always be as desirable for, let us say, a dye house or a bleachery, as one which would not meet the views of the sanitarian for some patho-

logical reason, but which really furnished a good and peculiarly desirable supply. But fortunately most often the most potable water of the large supplies is also equally the most desirable for technical use. The great bugbear for the large steam users is the cost of water, and if this could be reduced the advantage would be considerable and tend to prolong the contest of the steam engine against the gas engine. Water bills of \$30,000 and \$40,000 a year are not uncommon in the vicinity of New York.

In the district we have under consideration there is a great variety of water supplied.

Yonkers obtains its supply mostly from wells and a small river. The present supply of The Bronx is obtained from the Bronx and Byram Rivers, and partly from the inflowing Croton supply. The latter is the great source of supply to the city. Brooklyn is obliged to rely upon the water pumped from beneath the surface of Long Island, although at present estopped from drawing from Suffolk County. Staten Island is in a very serious situation. The state of New Jersey forbids the diversion of stream waters from that state into New York and consequently Staten Island. Staten Island has some local water from springs and wells, and many manufacturers are using water from wells sunk by themselves. Almost all of these yield water of excessive hardness unsatisfactory for both domestic and technical use. The supply of water from Brooklyn to Staten Island would be difficult in an engineering way by reason of the crossing of the Narrows, and moreover it would be some years before Brooklyn shall have any to spare. It was thought a supply of water might yet come to Staten Island from New Jersey, sent by pipe lines from water works pumping only from wells, which had been said to be a diversion allowable as distinct from that of stream water; but a decision just rendered adverse to this view in the Supreme Court of that state a few days ago again puts an embarrassing question before New York City in doing justice to Staten Island. If this admirable territory is to advance by the location of large industries, a water survey and a water project must be at once provided for.

Almost equally urgent is the consideration of the water supply of all that part of the territory we are considering which lies entirely in New Jersey. Its population will now grow rapidly by reason of tunnel construction accomplished and bridge construction promised; the growth will be out of proportion to that of the last decade; the consumption of water for power and technical uses will grow as the borders of these bays and streams and the filled in areas of the meadows are taken up by large industries and the ones already established. Some of the water companies already supplying portions of this territory are close to the limit of their resources, and the largest of them could hardly expect to meet the demand of the future. Much of the supply is drawn from wells which will be abandoned as communities grow closer to them, thus

adding to the demand on the larger supplies.

A solution of the difficulty for New York in its Staten Island supply, and for New Jersey in its eastern cities supply, is to be found in the eradication, by treaty, for this if for no other purpose, of the state line of demarkation and the treatment of the water question as of common concern to all. If the states and the counties recognize no lines of distinction, the following would be the sources to be availed of in the future as a universal system:

Underground Long Island (Queens, Nassau and Suffolk Counties).

The Bronx and Byram Rivers.

Yonkers wells.

Staten Island wells.

Croton system.

Hudson River at Hyde Park.

Catskill and Esopus system.

Passaic River system.

Rockaway River system.

Hackensack River system.

Pequanock Valley system of Newark.

Perth Amboy wells.

If Brooklyn should draw all that is needed from Long Island; if Staten Island be allowed to draw from New Jersey and in return for this concession New York permit its Catskill line to be tapped at Cornwall for the supply of that part of the territory under consideration lying on the same side of the Hudson, all groups and consuming centers and intercommunicating fields would be supplied with the maximum of economy, the minimum of further outlay and the maximum of technical and sanitary purity. But a cry of horror will go up from the New York City taxpayer when he is told of a proposition that contemplates giving advantage to residents of New Jersey of what shall have been acquired by him at a cost beyond his willingness at present to sit down and calculate. But this is just what he should do for his own financial salvation.

THE CATSKILL WATER PROJECT HAS BEEN UNWARRANTED BY THE FACTS.

In the first place the estimate of the population of the future and of the per capita consumption were reached in a faulty manner. They are both too high. The diagrams submitted by the City of New York Board of Water Supply giving the consumption and population, Manhattan and The Bronx, 1900 to 1940, show how gratuitous was the assumption of the persistence for thirty years of the present rate of increase.

Secondly, the resistance of Suffolk County to draft of water from its subterranean territory could have been overcome by offers to purchase the right, thus resulting in such an income for that county that they would have been rich beyond the dreams of avaricious counties. The county's watershed could yield over two hundred million gallons per day, and it could not use one-tenth of that in its most likely crowded condition.

Thirdly, the storage capacity of the Croton system

can be still further increased, as it has been by the Cross River Reservoir.

Fourthly, the continued overflow of the Croton, amounting to as much as five hundred million gallons per day for the entire period of this spring, shows that the surplus that could be availed of will continue to be an important factor in delaying the drawing down of the utmost utilized storage capacity.

Fifthly, the restriction of waste is no negligible factor, and could be introduced at any time that need was shown for it. At any rate, long before the high figure of 195 gallons per head should ever be approached.

Lastly, even admitting that some of these arguments would have tended to create dangerous unconcern in the minds of citizens, we have yet to face the fact that the new supply could have and should have been drawn from the Hudson River above the influence of tidewater.

I quote from Freeman, New York Water Supply, 1900, page 10:

"By taking water from the Hudson River at Poughkeepsie and filtering it, and by constructing storage reservoirs in the Adirondacks to let down water whenever in extreme drought there was any sign of brackishness in the Hudson water at Poughkeepsie, and then by filtering this Hudson water just as Poughkeepsie has done for its own supply from the Hudson for twenty-seven years, or as Albany is doing to-day, New York City can obtain any desired quantity even up to 800,000,000 gallons per day at a cost, including interest, maintenance, depreciation and sinking fund to pay off all costs of construction in forty years, for water delivered at the city limits at three hundred feet above sea level, less than \$50.00 per million gallons."

Also from the Burr, Herring, Freeman Commission on Additional Water Supply, 1904, page 43:

"This committee is of the opinion that by adopting proper precautions and also reinforcing the flow in time of drought from large storage reservoirs under the city's control to be established in the Adirondacks, the water taken from the river near Hyde Park could, by filtration, be rendered potable and entirely safe for drinking, domestic and industrial uses."

Although further on (pages 54 to 55), this project meets with unfavorable comment for fear of "mediocrity of management" in the pumping plant; yet at page 64 it is praised as "by far the most practicable and economical plan of taking water from the Hudson River for purposes of additional supply."

In the prosecution of the Catskill project many difficulties have been met with, and very large additions to the estimated cost are now admittedly necessary. The difficulty of crossing the Hudson River has become increasingly great. The point at which it is now said the crossing is to be made is at Cornwall, about fifty miles from the city. This aqueduct will thus have been brought to within forty miles of the center of the district we are considering, or about sixty

miles from Staten Island. To tap it there to go to New Jersey and Staten Island through the trans-Hudson River Valleys is to open a market at once for surplus goods whose production has cost too much to admit of neglecting any sale. Moreover, if this line could be put into commission several years before the completed line across the river the financial advantage will not be inconsiderable. Instead thereafter of expecting the private water companies of New Jersey to continue the erection of new reservoirs and lines to keep up with the increase of demand, co-operate with them and feed water into their mains whether by sale or after condemnation. In other words, let the people get the best water and the most water on the best terms.

Let the whole territory be considered as a unit of interest. Every factory established in eastern New Jersey is an asset for New York City and every dweller there a contributor to the wealth of New York City. Then when a population shall have grown up which consumes all of the present supplies and the Catskill supply, we shall still have the Hudson filtered water to draw upon and the Suffolk County supply. For twenty-five years before that time shall have arrived we will have been drawing a large income from the surplus Catskill water. We shall have been supplying to Staten Island in the most practical way what is difficult to supply across the Narrows, and we shall have been aiding to develop a fringe of New Jersey which, by almost every right, is practically our own city.

MATERIALS SUPPLY.

There are many considerations not touched upon before which point to the correctness of any view which sees a great technical industrial future for the enlarged metropolis. Such would be the excellent supply of materials—raw materials—coming by rail and by inland water and from overseas, and general materials for supplies and repair being quickly obtained. This latter is a source of economy and makes for ease of mind of the factory manager. Such also is the favorable market for skilled and unskilled labor. Another great advantage is the ease of importation and the facilitation of customs business. Manufacturing in bond for export should develop largely in such a district.

We might give a moment's consideration to the observation of how peculiarly certain industries have passed the district by. We have for instance practically no iron producing industry. The last blast furnace, that at Secaucus on the Meadows, went out of blast a few years ago. An old-established rolling mill for structural material at Paterson went into the hands of a receiver about two years ago. Another of pretentious size and new equipment, designed to manufacture open-hearth steel and roll structural shapes, met with a like fate during the panic. A wire rod mill making its own open-hearth steel at Astoria several years ago went the same way. Several crucible steel

works, however, are operating and prospering continuously. But there can be little question, and some good authorities interested in other districts have admitted it, that a blast furnace plant and a steel works for rail or structural shapes could, under proper conditions, be successful in this position. These conditions would appear to be the use of Cuban ore, as well as of Adirondack, Orange County and New Jersey ores, the manufacture of by-product coke, the utilization of the gases of both coke ovens and blast furnace and a continued supply of scrap. It is possible that the reduction of the duty on iron ore may help to bring such a project to realization. At any rate, we are almost certain to see, with the introduction of electric power the establishment of a considerable number of electrical steel furnaces.

Paper manufacture does not exist, if we except certain paper board manufactories, and it is not likely to be established. There is no manufacture of cement, and there is not to be any, though we may see clinker ground on a large scale and distributed in the surrounding country in bulk.

With this review we may dismiss our subject, but not without expressing a hope of seeing industrial happiness here continue and increase. Because that man is most blessed who is industrious, that city is the happiest which has the greatest proportion of contented workers. Our best monuments will not be pleasure palaces but healthful factories, comfortable homes, cheerful and beautiful buildings called for by the highest aspirations of a people living by toil but neither exhausted nor hopeless.

Therefore to lead this district to its best development is an accomplishment worthy of genius of the highest abilities in constructive statesmanship and practical economics.

CONCLUSIONS.

Enough has been said to indicate the truth of the following propositions:

1. The territory described and recognized as the great Metropolitan District is destined to be a most interesting technological center by reason of the establishment within it of the largest works in the world treating raw materials for the production of staples.

2. Its advancement would be more rapid if certain extensive improvements were made under some form of convention eliminating the disadvantages of separate state control.

3. A universal project for water supply is the most important of these improvements.

4. Reclamation of large sunken areas adjacent to deep water to adapt them to normal uses of land is the next most important improvement.

5. Introduction of electric power from the nearest large hydraulic conservation works in both states is an improvement which gives promise of most extraordinary advantages, particularly for electro-chemical and electro-metallurgical development similar to that at Niagara Falls.

TESTING OIL FOR STEAM TURBINES.*

By ROBERT JOB.

Of Booth, Garrett & Blair, 404 to 406 Locust St., Philadelphia, Pa.

The lubrication of heavy rapidly-moving machinery is of extreme importance owing to the necessity of continuous running. In many places the heating of a bearing may result in cutting off power, with the attendant inconvenience and loss. At times, as for instance in some types of steam turbines, the bearings are very closely adjusted and, if the oil is not entirely clear from waxy substances, clogging and heating very quickly results. In many places also oil is used in a "system" or, in other words, in a large tank which frequently holds thousands of gallons. This oil is pumped above the bearings and allowed to flood them, and thus is used over and over again. In course of time it has been found that with some oils a settling of a waxy sludge results, causing clogging of the filters and other difficulties.

In view of these conditions it was thought desirable to investigate carefully to determine whether some simple test could not be developed which could be used in connection with routine examinations of shipments in order to bar out this undesirable quality.

As an aid in studying the subject a number of red engine and turbine oils some of which had given good service and others bad service were thoroughly tested and it was found that the usual constants gave no indication of the service obtained in this particular. Clearness and freedom from all turbidity were of importance, but mere color, or lack of color, seemed to have little influence and good service results were obtained with oils which were of a red color, as well as with those which were filtered to an amber color.

Heating Test.—After experimenting with a number of tests, it was found that on heating the oils to a temperature of 450° F. all of the oils which had given bad service showed a very marked darkening of color, while those which had proved satisfactory showed very little change. Our investigations indicated that filtering to a light color, as for instance that of a "sun-bleached" oil, is unnecessary, since good results have been obtained even under exacting conditions with oil of fairly deep color. But the point of importance appeared to be that the oil had been filtered or else had been chemically treated in such manner that the waxy substances, the so-called "anorphous waxes," had been completely removed, and on applying the heating test only a slight darkening of color resulted. It seems, therefore, to be of decided advantage in addition to other requirements to specify that an oil for the above purposes on being heated to a temperature of 450° F. and held there for five minutes shall show not more than a slight darkening of color. The test, of course, is that commonly used in test of 300° oil for burning purposes.

Separating Test.—It is known that the elimination of the waxes causes a decided increase in the ease with which the oil separates from hot water when thoroughly shaken with it, and this condition can be taken advantage of by prescribing that when one ounce of the oil is placed in a 4-oz. sample bottle with two ounces of boiling water, the bottle corked and shaken hard for one minute and let stand, the oil must separate from the water within a specified time, depending upon the nature of the oil, and that there must be no appearance of waxy substances at the line of demarcation between the oil and the water.

These tests are simple and practical, and seem to give an excellent index, in conjunction with the usual tests, of the service value of oils used under these conditions of service.

GRAVIMETRIC FACTORS AND THEIR LOG-ARITHMS.

By LESTER M. HAWK.

Chief Chemist, Dexter Portland Cement Co., Nazareth, Pa.

The following table of analytical factors has been calculated from the atomic weights as reported by the International Committee, for 1909. As numerous changes were made in this report, the recalculation of the analytical factors to agree with this seemed advisable. The table has been carefully checked to guard against errors.

TABLE OF GRAVIMETRIC FACTORS AND THEIR LOGARITHMS

Found	Sought	Factor	Logarithm
Al ₂ O ₃	Al.....	53034	-1.72455
".....	Al ₂ (SO ₄) ₃	3.35041	0.52509 +
Pt.....	NH ₄	17471	-1.24231 +
".....	NH ₄ OH.....	18505	-1.26729
".....	NH ₄ OH.....	35949	-1.55569
".....	NH ₄ Cl.....	54875	-1.73937
".....	(NH ₄) ₂ SO ₄	67772	-1.83105
(NH ₄) ₂ PtCl ₆	NH ₄	07676	-2.88511
".....	NH ₄ OH.....	68130	-2.91009
".....	NH ₄ OH.....	13794	-1.19849
".....	NH ₄ Cl.....	24108	-1.38217
".....	(NH ₄) ₂ SO ₄	29775	-1.47385
NH ₄ Cl.....	NH ₄	18388	-1.50294
".....	NH ₄ OH.....	33722	-1.52792
".....	NH ₄ OH.....	65512	-1.81632
".....	(NH ₄) ₂ SO ₄	1.23503	-0.09168
(NH ₄) ₂ SO ₄	NH ₄	25779	-1.41126
".....	NH ₄ OH.....	27305	-1.43624
".....	NH ₄ OH.....	53044	-1.72464
".....	NH ₄ Cl.....	80970	-1.90832
Sb ₂ O ₃	Sb.....	78975	-1.89749
".....	Sb ₂ O ₃	94746	-1.97656
".....	Sb ₂ O ₃	1.05256	0.02225
".....	Sb ₂ S ₃	1.10581	0.04368 +
".....	2K ₂ SO ₄ C ₂ H ₅ O ₄ + H ₂ O.....	2.18363	0.33918 +
Sb ₂ S ₃	Sb.....	71418	-1.85381
".....	Sb ₂ O ₃	85680	-1.93288
".....	Sb ₂ O ₃	95185	-1.97857
".....	2K ₂ SO ₄ C ₂ H ₅ O ₄ + H ₂ O.....	1.97465	0.29549 +
Sb.....	Sb ₂ O ₃	1.09969	0.07907

*Read at the Twelfth Annual Meeting American Society for Testing Materials, Atlantic City, N. J., June 29 to July 3, 1909.

Sb	Sb ₂ S ₃	1.33279	0.12476	Cr ₂ O ₃	K ₂ CrO ₇	1.93432	0.28653
"	Sb ₂ S ₅	1.40020	0.14619 +	BaCrO ₄	Cr	20555	-1.31291
"	2KSnOC ₂ H ₃ O ₂			"	Cr ₂ O ₃	30023	-1.47745
As ₂ S ₃	2H ₂	2.76491	0.41169 -	"	PbCrO ₄	1.27591	0.10554
"	As ₂ O ₃	6.0923	-1.78478	"	K ₂ CrO ₄	76655	-1.88454
"	As ₂ O ₅	8.0420	-1.90536	"	"		
"	As ₂ O ₃	9.3416	-1.97042	"	K ₂ Cr ₂ O ₇	58074	-1.76398
As ₂ S ₅	As	48332	-1.68424	Co	CoO	1.27132	0.10426
"	As ₂ O ₃	63800	-1.80482	CoO	Co	78658	-1.89574
"	As ₂ O ₅	74110	-1.86988	CoSO ₄	Co	38035	-1.58019
Mg ₂ (NH ₄) ₂	As	39396	-1.59546	"	CoO	48356	-1.68445
As ₂ O ₃ - H ₂ O	As ₂ O ₃	52004	-1.71604	3K ₂ SO ₄ ·2CoSO ₄	Co	14160	-1.15107
"	As ₂ O ₅	60409	-1.78110	"	CoO	18003	-1.25533
Mg ₂ As ₂ O ₇	As	48287	-1.68383	Cu	CuO	1.25171	0.09750
"	As ₂ O ₃	63740	-1.80441	"	Cu ₂ O	1.12583	0.05147 +
"	As ₂ O ₅	74040	-1.86947	"	Cu ₂ S	1.25223	0.09768 +
BaCrO ₄	Ba	54195	-1.73396	"	CuSO ₄ ·TH ₂ O	3.92831	0.59420 +
"	BaO	60507	-1.78181	Cu ₂ S	Cu	79858	-1.90232
"	BaCO ₃	77567	-1.89135	CuO	Cu	79892	-1.90250
BaCO ₃	Ba	69600	-1.84261	Cu ₂ (CNS) ₂	Cu	52258	-1.71815
"	BaO	77707	-1.89046	CaF ₂	F	48661	-1.68718
BaSO ₄	Ba	58845	-1.76971	"	HF	51244	-1.70964
"	BaO	65699	-1.81756	SiF ₄	F	72867	-1.86253
"	BaCO ₃	84548	-1.92710	"	HF	76732	-1.88498
CO ₂	BaCO ₃	4.48574	0.65183 +	"	CaF ₂	1.49743	0.17534 +
Bi	Bi ₂ O ₃	1.11541	0.04743	Au	AuO	1.68113	0.03388
"	BiONO ₃	1.37508	0.13833 -	AgI	I	54054	-1.73283
Bi ₂ O ₃	Bi	89654	-1.95257	"	HI	54584	-1.73627
"	BiONO ₃	1.23281	0.09089 +	Ag	I	1.17648	0.07059 -
Bi ₂ S ₃	Bi	81216	-1.90964	"	HI	1.18585	0.07402
"	BiO	87464	-1.94183	Pd	I	2.37904	0.37640 -
"	BiONO ₃	1.11678	0.04796 +	PdI ₂	I	70405	-1.84760
B ₂ O ₃	B	31428	-1.49732	Fe	Fe ₂ O ₃	1.42971	0.15525
"	H ₂ BO ₃	1.77211	0.24849 -	"	Fe ₂ O ₄	1.38198	0.14051 -
"	N ₂ B ₂ O ₇ + 10H ₂ O	2.72973	0.43612	"	FeO	1.28650	0.10941
KBF ₄	B	8723	-2.94067	"	FeS	1.57425	0.19707
"	B ₂ O ₃	27756	-1.44335	"	FeSO ₄ ·5H ₂ O	4.33310	0.63680
"	H ₂ BO ₃	49186	-1.69184	Fe ₂ O ₃	Fe	69943	-1.84475
"	N ₂ B ₂ O ₇ + 10H ₂ O	75765	-1.87947	"	FeO	83983	-1.95416
AgBr	Br	42556	-1.62896	"	Fe ₂ O ₄	96658	-1.98524
"	HBr	43092	-1.63440	"	FeS	1.10177	0.04182
Ag	Br	74083	-1.86972	"	FeSO ₄ ·5H ₂ O	3.03073	0.48155
"	HBr	75017	-1.87516	FeS	Fe	63523	-1.80293
Cd	CdO	1.14234	0.05780	"	Fe ₂ O ₃	90820	-1.95818
"	CdS	1.28532	0.10901	Pb	PbO	1.07725	0.03232
CdO	Cd	87538	-1.94220	PbSO ₄	Pb	68311	-1.83449
"	CdS	1.12515	0.05121	"	PbO	73588	-1.86681
CdSO ₄	Cd	53916	-1.73172	"	PbO ₂	78866	-1.89680
"	CdO	61591	-1.78952	"	Pb ₂ O ₃	76227	-1.88211
"	CdS	69300	-1.84073	"	Pb ₂ O ₄	75348	-1.87707
CaO	Ca	71475	-1.85415	PbSO ₄	Pb	78890	-1.89702
"	CaCO ₃	1.78443	0.25150	"	PbCO ₃	88100	-1.94498
"	CaSO ₄	2.42751	0.38516 +	"	(PbCO ₃) ₂ Pb(OH) ₂	85246	-1.93067
CaCO ₃	Ca	40055	-1.60265	"	Pb(C ₂ H ₃ O ₂) ₂ +		
"	CaO	50040	-1.74850	"	2H ₂ O	1.25076	0.09518
"	CaSO ₄	1.36039	0.13366	"	PbCrO ₄	1.06606	0.02778 +
CaSO ₄	Ca	29443	-1.46899	PbO ₂	Pb	86616	-1.93760
"	CaO	41195	-1.61484	"	PbSO ₄	1.26796	0.10311
"	CaCO ₃	73508	-1.86634	PbCl ₂	Pb	74492	-1.87211
CO ₂	CaCO ₃	2.27472	0.35694 -	"	PbO	1.09048	0.03762
"	CaO	1.27471	0.10544	"	Li ₂ CO ₃	1.18919	-1.27690
"	C	27273	-1.43573	"	LiCl	1.14758	0.05078
BaCO ₃	CO	63637	-1.89371	Li ₃ PO ₄	Li	18103	-1.25776
"	CO ₂	60689	-2.78390	Li ₂ SO ₄	Li	12719	-1.10446
BaSO ₄	CO ₂	22203	-1.34817	"	Li ₂ O	27255	-1.43545
"	C	65140	-2.71100	"	LiCO	67230	-1.82756
"	CO ₂	18848	-1.27527	"	LiCl	77150	-1.88734
AgCl	Cl	24738	-1.39337	LiCl	Li	16486	-1.21712
"	HCl	25442	-1.40555	"	LiO	35328	-1.54811
Ag	Cl	32870	-1.51680	"	Li ₂ CO ₃	87140	-1.94022
"	HCl	33804	-1.52898	"	Li ₂ SO ₄	1.29615	0.11266
NH ₄ Cl	HCl	68163	-1.83355	Mg	MgO	1.65792	0.21956
Cr ₂ O ₃	Cr	68463	-1.83546	"	MgO	60317	-1.78044
"	Cr ₂ O ₃	1.31536	0.11905	"	MgCO ₃	2.09129	0.32041
"	PbCrO ₄	4.24710	0.62809	"	Mg	28842	-1.46003
"	K ₂ CrO ₄	2.55324	0.40709	"	MgO	47818	-1.67959
				"	Mg ₂ P ₂ O ₇	21847	-1.33938

Mg ₂ P ₂ O ₇	MgO	36219	-1.33894	Ag ₂ O	80812	-1.90764
"	MgCO ₃	75714	-1.87935	AgNO ₃	1.18521	0.07380
"	MgSO ₄ + 7H ₂ O	2.21435	0.34525	Ag ₂ O	1.07417	0.03107
CO ₂	MgCO ₃	1.91636	0.28248	AgCl	1.32872	0.12343
"	MgO	91636	-1.96207	Na ₂	1.34781	0.12963
Mn	MnO ₂	1.58255	0.19936	NaCl	2.54172	0.40513
MnO ₂	Mn ₂ O ₃	63189	-1.80064	Na ₂ O	1.72450	-1.59487
Mn ₂ O ₃	Mn ₂ O ₄	72027	-1.85749	Na ₂ SO ₄	1.21597	0.08461
"	MnO	93006	-1.96085	Na ₂ SO ₃	32379	-1.51026
"	MnO ₂	1.13987	0.05685	Na ₂ O	43641	-1.63989
Mn ₂ P ₂ O ₇	Mn ₂ O ₃	38702	-1.58773	NaCl	82298	-1.91539
"	MnO	49974	-1.69875	Na ₂ O	1.88581	0.27550
"	MnO ₂	61247	-1.78709	Na ₂ SO ₄	74194	-1.87037
MnSO ₄	Mn ₂ O ₃	63138	-1.80029	Na ₂ SO ₃	54190	-1.73392
MnSO ₄	Mn ₂ O ₄	36378	-1.56083	Na ₂ O	40784	-1.61049
"	MnO	46973	-1.67185	SrO	81560	-1.92716
"	MnO ₂	57569	-1.76019	Ag	"	"
CO ₂	MnO	1.97568	0.29572	AgCl	"	"
Hg	HgO	1.04000	0.01703	SrO	"	"
"	HgO	1.08900	0.03342	"	"	"
"	HgCl	1.17729	0.07089	"	"	"
"	HgCl ₂	1.35460	0.13181	"	"	"
"	HgS	1.16036	0.06459	"	"	"
"	HgO	86180	-1.93541	"	"	"
"	HgO	89628	-1.95244	"	"	"
"	HgO	93074	-1.96883	"	"	"
"	HgCl	1.01459	0.00630	"	"	"
"	HgCl ₂	1.16740	0.06722	"	"	"
"	Hg	84940	-1.92911	"	"	"
"	HgO	88336	-1.94614	"	"	"
"	HgO	92594	-1.96658	"	"	"
PbMoO ₄	Mo	26151	-1.41749	"	"	"
"	MoO ₃	39226	-1.59358	"	"	"
MoO ₃	Mo	66667	-1.82391	"	"	"
"	MoO ₂	88890	-1.94885	"	"	"
Ni	NiO	1.27265	0.10471	"	"	"
NiO	Ni	78576	-1.89529	"	"	"
NiSO ₄	Ni	37919	-1.57886	"	"	"
"	NiO	48258	-1.68357	"	"	"
NH ₄ Cl	N	26186	-1.41807	"	"	"
"	HNO ₃	1.17784	0.07110	"	"	"
(NH ₄) ₂ PtCl ₆	N	06313	-2.80024	"	"	"
"	HNO ₃	28397	-1.45327	"	"	"
Pt	N	14369	-1.15744	"	"	"
"	NHO ₃	64636	-1.81047	"	"	"
NH ₃	N	82248	-1.91513	"	"	"
N ₂ O ₂	N	46684	-1.66984	"	"	"
PdI ₂	Pd	29594	-1.47120	"	"	"
Mg ₂ P ₂ O ₇	P	27847	-1.44478	"	"	"
"	P ₂ O ₅	63780	-1.80468	"	"	"
"	Ca ₃ P ₂ O ₇	1.39359	0.14413	"	"	"
(NH ₄) ₂ 11MoO ₄	P	01789	-2.25253	"	"	"
"	P ₂ O ₅	04097	-2.61243	"	"	"
K	K ₂ O	1.20458	0.08084	"	"	"
K ₂ PtCl ₆	K	16092	-1.20661	"	"	"
"	K ₂ O	19384	-1.28745	"	"	"
"	KCl	30686	-1.48694	"	"	"
"	K ₂ SO ₄	35862	-1.55463	"	"	"
K ₂ O	K	83016	-1.91916	"	"	"
K ₂ SO ₄	K	44872	-1.65198	"	"	"
"	K ₂ O	54053	-1.73282	"	"	"
"	KCl	85568	-1.93231	"	"	"
"	K	52441	-1.71967	"	"	"
"	K ₂ O	63170	-1.80051	"	"	"
"	K ₂ SO ₄	1.16867	0.06769	"	"	"
KClO	K ₂ SO ₄	71097	-1.85185	"	"	"
"	K	31903	-1.50383	"	"	"
"	K ₂ O	38430	-1.58467	"	"	"
"	KCl	60836	-1.78416	"	"	"
Ag	KCl	69115	-1.83957	"	"	"
AgCl	KCl	52016	-1.71614	"	"	"
SiO ₂	Si	46932	-1.67147	"	"	"
AgCl	Ag	75262	-1.87657	"	"	"

It is estimated that the North American Lead Co., of Missouri, in 1908 turned out 100,000 pounds of cobalt oxide. This is the first year that this material was manufactured in such large quantity.

The estimation of lime by the sugar method consists in determining the hydrate or available CaO_2H_2 , taking advantage of the solubility of that substance in a solution of sugar. The carbonate is insoluble in sugar. The lime is agitated with sugar-solution, and filtered, after which the lime is estimated by the ordinary alkalimetric method. Forty parts of sugar in 100 parts of water will hold in solution $11\frac{1}{2}$ parts of CaO .

Conveyors going up an incline and fed uniformly, can usually go up an angle whose tangent is greater than the co-efficient of friction of material on the belt, because the material forms a back stop all the way up the incline. But if the feed is intermittent, the material is apt to get started down the incline and the motion of the belt will have no influence on the motion of the material.

Conveyors should be fed so that the material is delivered in the direction of motion of the belt and with the same velocity as the belt is moving, if possible. The writer has devised a spout to accomplish this purpose and adjustment is possible to suit various kinds of material and different belt speeds. The spout is also made with a bar screen bottom which lets the fine material through onto the belt first which makes a cushion on which the larger lumps fall and saves a great deal of wear on the belt. It is not advisable to make small conveyors, such as 12-in. belts, too long, for the material will shift some and lose off before it reaches the end of the conveyor, and liberal allowance in capacity should be made if such a conveyor is installed.

The problem of belt conveyor capacity should be studied carefully and the allowances should be liberal. There have been very many disappointments in results caused by a too hasty decision or too great a desire to keep the first cost down.

Most firms are willing to help the purchaser, and it is usually a good plan to take up the matter of capacity with the manufacturer. It is not always easy for the manufacturer to find out all the conditions within so short an interval of time as he usually has at his disposal, and unless the manufacturer has had considerable experience with this type of conveyor, the purchaser may be led to install apparatus which gives him very disappointing results.

A new use has been found for metallic sodium in the drying of transformer oils. With these oils the insulating qualities rise in proportion as the moisture in them decreases. Experiments made with them indicate that all of the water may be completely removed from the oils by the use of metallic sodium. The usual method of using the metal consists in adding the sodium to the oil, about one ounce to the barrel. If much hydrogen is evolved, this will indicate that there is much water in the oil, and the balance of the sodium should be carefully added in small amounts. The oil is then stirred up three or four times a day for a minute at a time. After several days the oil may be removed and tested. It has been found that oils which broke down at 300 volts had their breaking point raised to 20,000 volts or higher by this treatment.

The Assyrians used asphaltum for waterproofing the immense irrigation canal built 4,000 years ago, and their sources of supply, the fountains of Is, on a tributary of the Euphrates, still yield.

COATING SOUNDING TUBES,

By CHARLES E. MUNROE.

Professor of Chemistry, the George Washington University, Washington, D. C.

It is well known that in many places the land dips so gradually under the sea that the approach toward the shore may be detected at a considerable distance from it by sounding, and hand sounding, with lead and line, has long been practiced. This operation, however, is a difficult one to carry out, except in quite shallow water and when the vessel is nearly at rest. It is obvious that greater safety in navigation was attained when Sir William Thomson (Lord Kelvin) invented his sounding machine,¹ since by its use it has become possible to take flying soundings in depths of from 50 to 100 fathoms, every 10 minutes, while the vessel is making 14 to 18 knots per hour. This he accomplished by using wire in place of the old hempen lead line and applying Mariotte's law in measuring the depth attained, thus eliminating from consideration in the measurement the variable lengths of wire which must be payed out in attaining the same depth under different speeds. The depth is ascertained by means of a glass tube, closed by a cap at its upper end, which is enclosed in the sinker so as to be kept upright, and be protected from fracture, while the water has easy access to its open end. A pressure of five fathoms of sea water equals that of one atmosphere, and the water will rise the higher in the tube the deeper the device sinks below the surface of the sea. To record the height to which the water rises within the tube, and therefore the depth to which the weight sinks, the interior of the tube is coated with red silver chromate, which reacts with the salt in the sea water to form white silver chloride and soluble sodium chromate, which dissolves out, consequently the color is discharged from the coating on the tube to the highest point reached by the water.

It is apparent that a coated tube can be used but once for a given depth, or for anything less than that depth, and that it must be recoated for reuse. This process was a trade secret, and because of the inconvenience and expense of having to send the tubes considerable distances for treatment, attempts have repeatedly been made to ascertain how this recoating can be best accomplished. In the method devised by Surgeon Paul Burrill, of the Compagnie Générale Transatlantique, it is directed to shake up about 16.5 grams of finely ground silver chromate with 50 c.c. of photographic collodion, allow the mixture to stand for one-half hour and then use the supernatant liquid for coating the tubes. This mixture yields coatings which were found to be of a dull brownish red color, which react sluggishly with sea water, and which are apt to detach themselves from the tube. Experiments with albumen gave no better results, but gelatine was found

¹On Compass Adjustment of Iron Ships and on a New Sounding Machine, Sir William Thomson, J. Roy. United Service Institution 22, 90-114; 1874; and Sounding Machines for the Prevention of Strandings, Prof. Lambert, J. Roy. United Service Institution 35, 765; 1891.

to serve admirably as the medium for forming the film. At first the freshly prepared solid silver chromate was mixed with the medium, as in Burrill's process, but later it was found better and simpler to form the silver chromate within the medium. The coating liquid, as finally adopted, consisted of 100 grams of Le Page's liquid glue, to which was added, with stirring, first 3.4 grams of finely powdered silver nitrate and then 1.95 grams of finely powdered potassium chromate, the mixture being stirred with a glass rod until the bright red color was developed to its maximum brilliancy throughout the mass. This quantity of the mixture is sufficient to coat 10 dozen tubes.

In the meantime the tubes are cleaned for recoating by removing the caps from the top and immersing the tubes in concentrated sulphuric acid for about five minutes, so as to destroy the coatings left in them; then washing with water to remove acid; then immersing in ammonia water for about 10 minutes, to dissolve any silver chloride present; then washing with distilled water again; and then drying thoroughly. The coating is applied to the well dried tube by attaching a rubber bulb to one end, dipping the other end in the gelatine-chromate mixture and sucking the mixture up to the height of about 10 cm. when the bulb is removed, the tube overturned, and placed in a rack (like a test tube rack with a trough about it to receive the drip) to allow the excess liquid to flow down the tube. This viscous liquid flows slowly, hence the tubes are allowed to remain in the rack for 24 hours. The small plug of gelatine-chromate mixture, which has hardened in the end of the tube, is removed by inserting a fine wire and revolving it until the tube is clear, and then the tube is ready for capping. This is done by placing a disk of tin or copper foil on the end of the tube, filling the cap with molten sealing wax, forcing the tube into it and wiping the excess wax off from the outer walls of the tube. The use of the foil is recommended because it is essential that the interior length of the tube shall be invariable and it was found that where tubes had been capped without the use of the disk the sealing wax had been forced into them to varying extents.

When the tubes are prepared in the manner just described they are coated evenly with a translucent, brilliant red coating, which reacts instantly on contact with salt water, the color being sharply and immediately discharged to the height to which the water has risen within the tube. They are very sensitive and will remain so if stored in a cool, dry place, out of contact with the light, as the potassium nitrate seems to exert a preservative effect. If, however, they are heated or exposed to direct sunlight, the color changes and the sensitiveness decreases. After one hour's exposure to bright sunlight the coating of a finished tube had changed in color from brilliant red to dark chocolate. After resting a tube for an hour upon an ordinary steam heating radiator in operation the coating of the tube had become chocolate

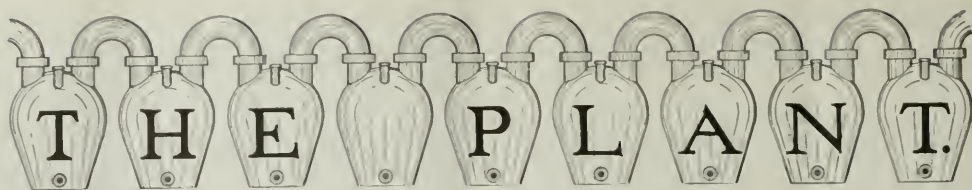
colored and opaque, and it had softened so as to run. The manufacturing operations must likewise be conducted in diffused light and in only a moderately heated room, to avoid changes of a similar nature to those just described taking place, and it is essential that the coating mixture should be prepared immediately before its application to the tubes. The process is so simple a one that it may easily be carried out on shipboard.

THE POWER OF PLASTER TO ABSORB SULPHUR FROM ILLUMINATING GAS.

Mr. Arthur D. Little, chemical expert and engineer, Boston, recently undertook to determine whether plaster serves to absorb sulphur gases from the air, and thus reduce the amount of sulphur below that which would naturally be expected in the room where gas is burned. The experiments were conducted in the room of an ordinary house having a contents of 615 cubic feet. The ceiling upon which investigations were made consisted of exposed calcimined plaster. With extensive chemical equipment and a fan for regulating the ventilation, it was possible to determine the manner of disappearance of the sulphur gases in the room. The gas was continuously burned, and the rate of absorption by the plaster was carefully determined. When the ventilation was greatly reduced it was found that the increase in the sulphur gases was not at all in proportion to what might have been expected. This was shown to be due to the fact that some of the sulphur was absorbed by the plaster. To such an extent was this the case that in one instance only about one-third of the expected amount was found in the air. When an excess of sulphur was discharged into the air the expected amount dropped to less than 10 per cent.

Analysis of the plaster of the experimental room at the beginning and during the experiments showed that there had been an actual increase in the sulphur which it contained, due to the absorption of sulphur gases from the air. In a word, the plaster had served as a medium by which sulphur was removed from the air. But it was shown that perhaps not all of the sulphur over and above that which disappears by the changing air is removed by the plaster, for a considerable portion of it may be removed with the water that condenses upon cold surfaces, particularly the walls. Mr. Little, however, made the interesting calculation that the plaster of a ceiling would serve to absorb sulphur gases from ordinary gas burning 25 feet per day during the probable existence of a house.

The first commercial metallic-filament lamp was the osmium lamp, invented by Auer von Welsbach in 1898. It became of commercial importance in 1902. The osmium filament takes 1.5 watts and the tantalum 1.7 watts for direct current, and somewhat more for alternating.



**METHOD OF CLAY CONTROL AS PRACTICED BY
THE WESTERN CANADA CEMENT &
COAL COMPANY, LIMITED.¹**

By J. G. DEAN.

Not long ago the writer had charge of manufacturing at a certain cement mill where the clay used in manufacturing was low in silica and high in iron oxide and alumina. The Silica-Alumina Ratio,

$$\frac{\% \text{ SiO}_2}{\% \text{ Al}_2\text{O}_3 + \% \text{ Fe}_2\text{O}_3}$$

would average a trifle less than 2.

When pure limestone was used with this clay it was nearly impossible to produce a cement that could be depended on for setting time and tensile strength, and if the lime content of the mix was high enough to burn properly in the kilns the cement would seldom pass the "boiling test."

In order to overcome this defect in the clay, it was necessary to mix the limestone from the upper strata of the deposit, which was siliceous in itself and carried in addition the sand and silt that filtered into it, to the purer stone from the bottom of the quarry. By this haphazard method we were able to keep the Silica Alumina Ratio high enough to produce a high grade cement.

This method required very careful mixing and grinding, as with cements having a low Silica-Alumina Ratio the limits of variation are extremely narrow. If the lime content is lowered the cement becomes erratic in its setting qualities and other peculiarities of over clayed cement. If the lime content is raised the cement will fail on constancy of volume tests and will require "air slaking."

These peculiarities become very complicated with such materials when they have been properly proportioned but improperly ground before burning. The mix on analysis will show it to be of the proper chemical composition. The burner will complain of its being "soft" or over clayed. The boiling test on the cement will reveal "free lime" and the tests for setting time and tensile strength will indicate an excess of clay, while the chemical analysis of cement will reveal nothing out of the ordinary. This would be a very confusing proposition to solve if it were not for the sieve test made on the mix previous to burning. This will show that that portion of the mix which was capable of combination was over clayed and the coarse particles of limestone in the mix were burned to "quick lime," consequently the resulting cement dis-

played the double characteristics of being over clayed and over limed.

One method suggested to improve the Silica-Alumina Ratio of this cement was to add the required amount of fine sand to each mix. With this sand to add a small percentage of fluor spar to aid in converting the sand so as to eliminate the extra grinding that would be necessary. These two materials were close at hand and could be easily procured but, as usually is the case, it is a hard proposition to convince those in authority that any improvements can be made in an article that has already made a reputation for quality.

In selecting the raw materials for the present company we were more fortunate as far as clay is concerned. We could not find any one clay material that would answer our purpose, so had to resort to a method of mixing to produce a material of the proper composition.

These two materials happen to be a shale and a slate. The shale has a Silica-Alumina Ratio of 3.00—3.80 and the Silica Alumina Ratio for the slate of 1.50—1.90, so that by mixing these two materials a clay can be produced having any Silica Alumina Ratio within the limits established by the materials themselves.

Both of these materials are found not far distant from the limestone deposit where the mill is located, and are hauled to the mill by dump-bottom cars by the Canadian Pacific Railway. The slate is dumped from the cars into track hoppers; is fed from the hoppers to a jaw-crusher, from which it is carried to the storage and dryer bin by a McCaslin overlapping bucket conveyor. This conveyor runs beneath the tracks and storage room in a tunnel, up over the dryer bin and the storage room in a dormer, across the tracks on a covered trestle and down to the tunnel through a tower. By placing hoppers in the storage floor that pierces the tunnel arch it is possible to use this conveyor for conveying the slate from the cars to the dryer bin and storage room or from the storage room to the dryer bin. It is also used to convey coal to the dryer furnace.

The slate is fed from the dryer bin to a 60' x 6' dryer by a Gates' rock feeder. This dryer is inclined $\frac{3}{4}$ " to 1' and has the distinction of having the furnace at the upper end. The draft is regulated by an electrically-driven fan at the discharge end. This method of firing has proven itself inefficient and very expensive. This calls for a water jacketed feeding spout, which is a source of considerable trouble. From the dryer the slate is elevated by a belt elevator to a No. $7\frac{1}{2}$ Krupp ball mill provided with a No. 25 mesh

¹Read at the Brooklyn meeting of the American Institute of Chemical Engineers.

screen. The crushed slate drops into an elevator boot and is elevated to a screw conveyor above the sample bins, where suitable slides are provided for dumping into the bins.

The shale is handled precisely in the same manner, excepting that it requires no crushing. There are six sample bins side by side for both materials, and as the bins are being filled a sample is taken from the conveyor automatically. When a bin is full this sample is quartered and analyzed.

In these analyses we do not separate the iron oxide and alumina as we have found by our analyses that the ratio of the alumina to the iron oxide in both raw materials are practically constant.

After the bin samples are analyzed the slate and shale are mixed according to the following formula:

$$X = \frac{MR_1 - S_1}{S_2 - MR_2} Y \text{ where}$$

M = Silica-Alumina Ratio desired.

S_1 = % SiO_2 in Slate.

S_2 = % SiO_2 in Shale.

R_1 = % R_2O_3 in Slate.

R_2 = % R_2O_3 in Shale.

X = Shale to be used.

Y = Slate to be used.

Either one of the latter is fixed by the scale limits.

The actual mixing is performed by drawing the slate and shale from the bottoms of the bins through a chute into screw conveyors, which convey the materials to elevators at the ends of the sample bins. These elevators dump the materials into two storage hoppers. These storage hoppers are provided with two hopper bottoms, each provided with valves immediately over the weighing hoppers. There are two weighing hoppers for each material, so that one can be filling while the other is unloading, making the process continuous. By suitable valves on the weighing hoppers, it is possible to discharge the two materials into the screw conveyor beneath at the proper rate, which is an important factor in such a method of mixing.

From the scale hoppers the mixed material is elevated and conveyed to a storage bin above the clay scales where it is mixed with the limestone.

The composition of the clay mixture is determined and is mixed with the limestone by the following formula:

$$X = \frac{S_2M - L_2}{L_1 - S_1M} Y \text{ where:}$$

X = weight of limestone.

Y = weight of clay.

M = Lime factor or "Hydraulic Modulus."

S_1 = % SiO_2 + % R_2O_3 in limestone.

S_2 = % SiO_2 + % R_2O_3 in clay.

L_1 = % CaO in limestone.

L_2 = % CaO in clay.

The limestone used is a very pure limestone so that

the clay matter introduced with it is so small that it seldom interferes with the Silica-Alumina Ratio established by the slate and shale mixing.

In arriving at our present standard of mixing we have been handicapped by not having the necessary instruments and apparatus to record the actual facts connected with each series of experiments. During the time that these experiments were in progress it was necessary to change coals several times so that we could not make any definite thermal comparisons. On account of climatic conditions and our method of drying, it was at times impossible to grind the final mix to the proper degree of fineness. Nevertheless the results of these experiments have been such that we feel confident that future improvements will not change our present standard to any appreciable extent.

By our present standard of mixing the value of M in slate and shale mixing = 2.40, and in the final mixing with limestone M = 1.91.

When the final mixture is ground so that 97% can be washed through a No. 100 sieve, and properly burned, the cement produced seems to be in chemical balance, possessing all the characteristic qualities of the highest grade Portland cement and with no erratic or freakish features.

With the few changes that are to be made in the drying and grinding of the raw materials we will be able to produce a cement that is absolutely uniform in composition and quality and one whose active elements are at all times under perfect control.

When cement manufacturers realize the numerous advantages that this System of Control possesses, I believe that it will come into general use.

Every manufacturer and user of cement realizes the importance of uniformity; and in order to produce a uniform cement the raw materials must necessarily be uniform. With this method of clay control we are able to produce a perfectly uniform clay and in a measure, correct the variations of the marl or limestone.

Coke is now being purchased on the basis of net dry weight by the smelters on the Pacific Coast. This has aroused much opposition from foreign shippers. Australian coke is usually low in moisture, but the European contains generally about eight per cent. The smelters allow three per cent without deduction from the gross weight of the coke. The determination is made upon fifteen-pound samples crushed to a half inch, dried in a steam-heated dessicator at a temperature of 240 degrees Fahrenheit.

Ferro-chrome usually runs 60 to 68% chromium. It is graded per unit of chromium and per unit of carbon, price increasing with chromium and decreasing with increase in carbon. If low in carbon, it is sometimes called "mild."

THE CHEMISTRY OF OPAQUE GLASS AND ENAMEL.

By ERIK ENEQUIST.

Ceramic Chemist and Manufacturer, Brooklyn, N. Y.

Opal or opaque glass has been known for many centuries, but the manner of producing it in the ages long ago was evidently not so systematic as in the present day. Gradual experimental discoveries have by degrees resulted in an approach to something like perfection.

In our generation opaque glass, under the name of "boneglass," has been extensively produced, and even to-day Bohemia, Germany and other countries furnish it in considerable quantities.

The opal effect in this product is believed to depend upon the formation of aluminum phosphate through the action of bone ash upon felspar, this aluminum phosphate crystallizing or separating upon the cooling or annealing of the glass. In late years, however, the use of fluorspar, fluorides, kryolith, etc., has become almost universal for the production of opaque vitreous bodies and the aim of this article is to attempt to explain the chemical reaction taking place in the opal glass producing pot.

The conclusion arrived at is that the opacity is caused by a gas called silicon fluoride, SiF_4 , which is produced by the action of fluorides upon silica. If fluorspar or fluorides of alkaline earths are used, a double decomposition takes place. Sodium fluoride and calcium carbonate are formed; the latter in turn is decomposed in the heat by sand or silica, SiO_2 .

In order to demonstrate the above I take about 1 pound of sand, $\frac{1}{2}$ pound of soda and $\frac{1}{2}$ pound of fluorspar and fuse them for a couple of hours. I then take out the crucible and break it upon cooling, when I find a rough semi-glass and a large button of sodium fluoride at the bottom of the crucible.

In a large way no such quantities of fluorspar are taken, as it would destroy the pot almost at once, but the reaction is the same, viz., the fluorspar is decomposed by the alkaline carbonates to alkaline fluorides, calcium carbonate, etc., as above. It must, however, be noted, that the SiF_4 reaction should follow as much as possible after the carbonic acid has left the pot.

There are abundant proofs to show that the opacity in glass depends upon a gas. If an opal piece of glass or enamel, particularly one containing lead, is heated to fusion, it becomes clear, the gas dissolving wholly in the glass; but if cooled, the gas is, so to say, precipitated or enclosed in the molecules of the glass, and the opacity results.

If the same or a similar piece of glass or enamel is heated as above and a part of the molten drop squeezed suddenly, with a pair of tongs, the opacity will practically vanish from the pressed part, the gas being driven into the other or molten piece of the glass, which fact seems to prove my contention.

If we examine any ordinary pressed opal ware we find that the glass is flinty, where the hot glass has

touched the cooler mold. The sudden chill has driven away the gas and the ware shows a trifling amount of flinty glass on the part of contact.

When a pot of opal glass has cleared, it smokes a great deal, the latter emitting a very strong odor. It is silicon fluoride. If the glass is left in the pot an extra 24 hours, and the heat is increased, flint glass or slightly colored glass will be the result; but not opal. All the costly gas will have evaporated by that time.

When the reaction, forming SiF_4 , has stopped taking place, depending upon the consumption of fluoride material, the gas slowly rises to the top of the pot. If at such a period the pot is suddenly cooled and then chilled and subsequently broken, it will be found that the lower part of the pot contains flint or clear glass but the top part opal glass.

Numerous experiments on my part have proven that lead has a great power to dissolve and hold SiF_4 , and I have finally settled on about 2% of lead in the batch. It will be found economical to use a little lead, because less of the fluoride material can be used. The saving in pots alone will pay for the lead used.

Some years ago there appeared on the market a preparation called "Opalin." This proved a very good material for opal work. It can be had to-day at 4 cents per pound.

The active substance in "Opalin" is sodium fluosilicate, Na_2SiF_6 , (25%), which decomposes in the heat as follows: $\text{Na}_2\text{SiF}_6 = 2\text{NaF} + \text{SiF}_4$, hence it furnishes silicon fluoride at a low temperature and more of it by the means of the sodium fluoride formed which is decomposed by the silica, as shown above. The balance in the "Opalin" is felspar and fluorspar.

From the nature of this opalin it will be seen that the claim that is made, that the pots are not attacked, is substantiated to a certain degree.

In the case of opaque or white enamel, it is of importance that the flat melting furnaces be abandoned because the SiF_4 will not dissolve and remain in the enamel unless the flame from the fire be excluded from contact with the same. The melting has to be done in pots with uniform heat and occasional stirring. Under the above conditions the whole cost, almost, of tin oxide can be saved as the SiF_4 produces a better opacity than the tin oxide.

PRACTICAL MANUFACTURE OF OPALE GLASS.

Numerous formulas are known to the trade, mostly without lead, but my experiments have shown me, as above stated, that some lead should be used.

Other formulas are very expensive, specifying large quantities of lead and potash.

Outside of fluorspar we have kryolith, alabastolite and rydolith, the respective values of which are approximately 6, 5, 4 and 3 cents per pound.

One of the most important features in connection with making opal glass is the temperature. This should be so regulated that a slow fusion takes place and no overheating occurs, in which case a double dan-

ger results, viz., the gas (SiF_4) forms in quantities before the carbonic acid gas, CO_2 , has left the pot; also, the glass becomes so liquid that it is not able to retain the SiF_4 and spoils.

When the batch is right and the heating has gone on gradually for about 12 hours, for a 1,000-pound batch or 15 hours for a 2,000-pound batch, the temperature and pot are carefully watched to observe when the glass clears; then some extra heat is given if possible; the pot should be cooled even more than is customary, so as to retain the maximum amount of gas. However, it is not so easy to do this, unless a factory is specially prepared for opal work.

My experiments with kryolith have shown that the pots are affected quickly. The evolution of SiF_4 is too sudden and therefore corrosive on the pots. Late discoveries have shown that alabastolite and rydolith produce a very white and satisfactory glass at a low cost.

Below I give four formulas that have been tried in a large way and have given good results, provided the above directions were strictly carried out.

In case a denser glass is desired, the amount of lead is increased and at the same time potassium carbonate is substituted for soda in proportions called for by their respective atomic affinities.

For opalescent sheet glass I recommend a batch of higher fusion point, than for instance for shades, etc.

I have observed the fact, which should be known to every glass manufacturer, that, the oftener a glass is fused, the higher becomes the fusing point. When a glass gets stringy or cordy, it often depends upon too much cullet or too many fusions. In such cases, alkali must be added, because each time a glass is fused some of the alkali volatilizes.

When cullet is used in the batch a lower fusing point for the batch is recommended. If a glass fuses too easily, add either cullet or increase the felspar or cut out some soda ash or fluorspar or both. If, on the contrary, the glass takes too long to turn or to clear, reverse the above.

If the opal pots burn out too quickly, it generally goes to show that the glass is too liquid, or that too much fluorides are used, or that not enough time is given for fusion.

By following the directions of fusion given in this article, a long life for the pots or tanks can generally be depended upon.

I consider any construction of tanks for making opal glass faulty if the flame is allowed to come in contact with the glass mass. The large excess of fluorine materials that have to be used quickly destroys the tanks.

If the opal glass turns out greenish it shows too much of a reducing flame in the furnace. Niter of course will almost always remedy this defect. Use both saltpetre and nitrate of soda. Use manganese in small quantities. This latter has no effect upon the color, unless the iron in the sand has a chance to melt into a ferric silicate by an oxidizing flame. A hard man-

ganese should be used; otherwise I would recommend arsenic acid, As_2O_5 , but not the common white arsenic of the formula, As_2O_3 , for which I have no use in my batches. Antimony is quite superfluous and should be dispensed with.

FORMULAS WITHOUT CULLET.

No. 1. <i>Soft Melting.</i>	No. 2. <i>Harder Melting.</i>
1000 Sand.	1000 Sand.
360 Soda.	340 Soda.
280 Felspar.	300 Felspar.
200 Fluorspar.	200 Fluorspar.
40 Red lead.	40 Red lead.
80 Rydolith.	80 Rydolith.
60 Alabastolite.	80 Alabastolite.
20 Nitrate of Soda.	20 Nitrate of Soda.
10 Saltpetre.	10 Saltpetre.
1 Manganese.	1 Manganese.

FORMULAS WITH CULLET.

No. 3. <i>Soft Melting.</i>
1000 Sand.
400 Soda.
300 Felspar.
200 Fluorspar.
40 Red lead.
80 Rydolith.
60 Alabastolite.
20 Nitrate of Soda.
10 Saltpetre.
1 Manganese.

Make half a pot of glass of formulas No. 1 or No. 2 without cullet, bail out as soon as glass is cleared. Use this as cullet for regular batches No. 3, just for a start. The general result will be a harder glass within a week of regular ranning, or after the composition of the cullet has become constant.

The pressure-drop of compressed air and illuminating gas flowing in pipes, as determined by Dr. Fritzsche of Dresden in 1908, is calculated by the formula:

$$p = 0.0602 G^2 v^{1.852} L / d^5 \quad .269$$

where G = weight of air or gas at the initial pressure p , in kg. per cu. metre, v = velocity of flow in metres per sec., L = length of pipe in metres, and d = internal diameter of pipe in millimetres; which expresses the drop, p , in kilograms per square centimetre.

Water for ice-making should be taken from the coolest possible source as a matter of economy in refrigeration. In some places artesian water is taken for this purpose. Such a case is that of the United Ice & Coal Co., at Harrisburg, Pennsylvania, where a cost-reduction of 30% is obtained in that way. Where water is abundant, cooling towers may be employed to reduce the temperature before freezing in the machines.

The U. S. patent office issued 33,514 patents last year, reissued 168 patents and registered 6,020 trademarks, labels and prints.

THE CHAMBER REGULATOR *

By HUGO PETERSON.

In the manufacture of sulphuric acid by the chamber process, difficulties in the functions of the Gay-Lussac tower are frequently experienced, whereby an increased amount of nitric acid is required, so that it is necessary to place an apparatus between the last chamber and the Gay-Lussac in order to prevent the denitrating action of end gases which are leaving the chambers.¹

The simplest and most durable apparatus for this purpose is a tower in which the end gases are brought in contact with an acid which is dripping down from the top of the tower. Such towers have been in use for many years but difficulties were experienced in the choice of the acid. Either a 60° acid containing N_2O_5 , or a 40 to 48° acid was used. It was found that a 60° acid, even if it contains large amounts of nitrore, is not qualified to condense the last particles of SO_2 as it does not contain sufficient water. It is known that sulphur dioxide can exist in the presence of nitrosyl-sulphuric acid in a strong sulphuric acid. On the other hand a 40 to 48° acid and even up to 53° is not able to deprive the end gases of their SO_2 contents as the nitrore is missing, and also the drying of the end gases cannot be accomplished as the acid is not sufficiently strong for this purpose.

The only acid which is capable of preventing the end gases from denitrating in the Gay-Lussac tower is a cold acid of about 55° Bé, within the limits of 53 to 57°, containing a large amount of nitrore. This acid not only cools the gases but dries them as well and absorbs the SO_2 contents of the end gases, as the acid contains enough water for condensation. It also removes an excessive amount of nitrore from the end gases, on account of its extremely high absorption capacity for N_2O_5 , thereby preventing a loss of N_2O_5 through the outlet of the Gay-Lussac tower. On the other hand, if the end gases are not sufficiently strong in their nitrore contents, the acid of the intermediate tower will give up the same, thus regulating the discharge of the nitrore from the Gay-Lussac. For these reasons the apparatus has been termed the "Chamber Regulator."

It is unnecessary to emphasize the importance of the regular supply of nitrore to the chambers. If insufficient steam is present in the last chamber to condense the sulphur dioxide gas, the acid of the chamber regulator will absorb the same on account of its water contents. By holding SO_2 in the after gases the formation of hyponitric acid (NO_2) is prevented.

Briefly stated the advantages attained upon using the chamber regulator are as follows: 1. Better condensation of the end gases. 2. Saving of nitric acid. 3. Increased production. 4. Obtaining of a stronger acid in the chambers.

Table I below shows the fluctuations in the density and the nitrore contents of the acid of the chamber

regulator during a test run of about four weeks. The data are taken from the plant of the Central Acid Company, in Seaton-Carew, England. The plant uses Australian zinc-blende with a lead content up to 12% and a sulphur content of 20 to 25%. For roasting, hand reverberatory furnaces are used, and the SO_2 contents of the gases is therefore of wide fluctuations, as shown in the tables below. The acid of the chamber regulator had to be strengthened several times during the course of the experiment by an acid of a higher specific gravity, which was taken from the Glover-acid reservoir. Tests made in a plant in North Germany where also Australian blendes were roasted yielded even more characteristic data, but the author is not allowed to publish these latter. In this case it was not necessary to strengthen the acid. Table IIb also shows the fluctuations in specific gravity and nitrore content, and Table II gives data of a system with pyrites roasting and shows the effect of the chamber regulator on the elimination of acid from the end gases. Before using the regulator, the end gases contained on an average 2.3 grams SO_2 per cubic meter, while by using the same the acidity was nil, except in a few cases where disturbances in the system occurred. The acidity was determined by absorbing the end gases

TABLE I.

Date	Temperature in the Chamber °C.			Vol.% SO_2 before entering Glover	° Bé of Acid at 15°C.	Nitrore Contents of Acid % HNO_3 36° Bé
6-29-08	78	55	40	5.5	55.5	2.88
6-30-08	83	60	42	5.3	55.0	1.95
7-1-08	83	57	45	5.5	55.0	1.10
7-2-08	85	62	40	6.4	57.0	3.12
7-3-08	80	61	41	5.0	57.0	5.56
7-4-08	81	62	40	5.6	58.5	3.90
7-6-08	74	45	33	5.4	56.0	3.39
7-7-08	75	50	32	4.9	55.5	3.73
7-8-08	72	43	30	4.8	55.5	3.49
7-9-08	75	52	32	4.8	55.5	3.12
7-10-08	70	50	35	6.0	56.0	2.78
7-11-08	68	48	30	4.4	56.0	1.88
7-13-08	72	58	42	5.0	54.7	1.24
7-14-08	74	54	36	5.1	54.5	1.10
7-15-08	68	55	35	4.3	54.0	1.05
7-16-08	66	55	37	4.4	54.5	1.04
7-17-08	70	56	38	5.9	53.5	0.78
7-18-08	62	48	32	4.8	54.7	0.32
7-21-08	50	32	25	3.8	54.7	1.30
7-22-08	54	42	34	2.6	54.7	1.32
7-24-08	70	55	39	4.2	53.5	1.10
7-25-08	75	50	37	6.4	54	1.32

in a standard solution of sodium hydrate. Tables IIIa and IIIb show a comparison of the SO_2 contents of the end gases before and after installing the chamber regulator. These data are also taken from the Central Acid Company. The analytical results are a little too high as the carbonic acid of the end gases is included in the acidity.

The already mentioned German plant where the same working conditions were observed, obtained a yield of 98% of sulphuric acid, figured on the roasted sulphur, during the first eight months after the regulator was installed. This is a decided improvement, as according to Lunge, the highest yield which is attained by the most up-to-date German and French acid works only amounts to 95% and less. The yield

*Translated from Chemiker Zeitung, XXXIII, April, 1909.

from pyrites roasting is almost 100%, as shown in Tables II and IIIb. Even at an efficiency of 98% the gain is considerable and the increase in production

TABLE II.	
Nitrose Contents	Grms Total SO ₂
Acid of Chamber Regulator	
° Bé at 15° C. (% 36° Bé HNO ₃)	in 1 cbm. Endgas
1.0	0.00
1.5	0.00
2.0	0.00
2.5	0.00
3.0	0.00
3.5	0.00
4.0	0.00
4.5	0.00
5.0	0.00
5.5	0.00
6.0	0.00
6.5	0.00
7.0	0.00
7.5	0.00
8.0	0.00
8.5	0.00
9.0	0.00
9.5	0.00
10.0	0.00
10.5	0.00
11.0	0.00
11.5	0.00
12.0	0.00
12.5	0.00
13.0	0.00
13.5	0.00
14.0	0.00
14.5	0.00
15.0	0.00
15.5	0.00
16.0	0.00
16.5	0.00
17.0	0.00
17.5	0.00
18.0	0.00
18.5	0.00
19.0	0.00
19.5	0.00
20.0	0.00
20.5	0.00
21.0	0.00
21.5	0.00
22.0	0.00
22.5	0.00
23.0	0.00
23.5	0.00
24.0	0.00
24.5	0.00
25.0	0.00
25.5	0.00
26.0	0.00
26.5	0.00
27.0	0.00
27.5	0.00
28.0	0.00
28.5	0.00
29.0	0.00
29.5	0.00
30.0	0.00
30.5	0.00
31.0	0.00
31.5	0.00
32.0	0.00
32.5	0.00
33.0	0.00
33.5	0.00
34.0	0.00
34.5	0.00
35.0	0.00
35.5	0.00
36.0	0.00
36.5	0.00
37.0	0.00
37.5	0.00
38.0	0.00
38.5	0.00
39.0	0.00
39.5	0.00
40.0	0.00
40.5	0.00
41.0	0.00
41.5	0.00
42.0	0.00
42.5	0.00
43.0	0.00
43.5	0.00
44.0	0.00
44.5	0.00
45.0	0.00
45.5	0.00
46.0	0.00
46.5	0.00
47.0	0.00
47.5	0.00
48.0	0.00
48.5	0.00
49.0	0.00
49.5	0.00
50.0	0.00
50.5	0.00
51.0	0.00
51.5	0.00
52.0	0.00
52.5	0.00
53.0	0.00
53.5	0.00
54.0	0.00
54.5	0.00
55.0	0.00
55.5	0.00
56.0	0.00
56.5	0.00
57.0	0.00
57.5	0.00
58.0	0.00
58.5	0.00
59.0	0.00
59.5	0.00
60.0	0.00
60.5	0.00
61.0	0.00
61.5	0.00
62.0	0.00
62.5	0.00
63.0	0.00
63.5	0.00
64.0	0.00
64.5	0.00
65.0	0.00
65.5	0.00
66.0	0.00
66.5	0.00
67.0	0.00
67.5	0.00
68.0	0.00
68.5	0.00
69.0	0.00
69.5	0.00
70.0	0.00
70.5	0.00
71.0	0.00
71.5	0.00
72.0	0.00
72.5	0.00
73.0	0.00
73.5	0.00
74.0	0.00

Year	Mean $\bar{C}_t$ (°C)	NO ₃ ⁻ (mg/L)	Com. Enrich
8-27-08	54.7	2.34	none
8-28-08	54.5	2.22	none
8-29-08	54.4	2.31	none
8-30-08	54.4	2.39	not determined
8-31-08	54.1	2.03	0.34
9- 1-08	53.9	1.84	none
9- 2-08	54.8*	2.21	none
9- 3-08	55.1	2.99	none
9- 4-08	54.5	2.55	none
9- 5-08	53.9	2.03	none
9- 6-08	54.4	2.25	not determined
9- 7-08	54.8	1.89	none
9- 8-08	54.5	2.51	none
9- 9-08	54.4	1.98	0.34
9-10-08	55.0	2.35	none
9-11-08	55.0	2.35	none
9-12-08	55.2	2.31	none
9-13-08	55.2	2.70	not determined
9-14-08	55.0	2.99	none
9-15-08	55.2	2.20	0.69
9-16-08	55.2	2.11	0.34

*A small rubber or glover acid was added to the acid of the chamber regulator.

amounts to about 600 tons of acid for a plant yielding 20,000 tons of 50° Bé sulphuric acid per year, without causing any extra expense.

To calculate the constructing costs of a chamber regulator the following data are given. The construction of the tower is the same as the Gay-Lussac and the space required amounts to only 0.2% of the total chamber space for 18—24,000 cu. ft. chamber capacity, 0.3% for 12—18,000 cu. ft. and 0.4 to 0.5% for smaller systems. The effect of the chamber regulator as a producing tower consists principally in the high nitrose contents of its acid. An extremely high yield of acid in the regulator was obtained at the "Kunigundenhütte" near Kattowitz in Germany. The tower which was installed two years ago and equipped with a cheap filling material had a total capacity of 225 cu. ft. and

TABLE III A.

Date.	Temperature of Chambers. ° C.			Nitrose at 15° C.		Intermediate Tower.		Grains Total SO ₂ per cubic foot End gas.	H ₂ O ₂ Con- tent.	Wt. of K ₂ SO ₄ Kilns.
	1	2	3	° Be.	Con- tents.	° Be.	Con- tents.			
6-8-08	66	52	37	60.9	1.72	53.3	0.44	3.5		10375
6-9-08	63	50	38	61.4	1.34	52.7	0.10	3.5		7034
6-10-08	61	52	38	61.4	1.56	52.4	0.10	3.5		10877
6-11-08	65	54	42	61.4	1.18	52.7	0.02	3.5	First week	16085
6-12-08	72	57	43					3.9	%	12733
6-13-08	60	45	41	61.8	1.39	56.6	1.89	3.9		982
6-14-08	68	54	41					3.9		13552
6-15-08	66	55	45	62.3	1.22	55.5	0.16	11.1		12475
6-16-08	70	60	46	62.1	1.78	55.8	0.25	11.1		13552
6-17-08	77	60	46	61.8	1.81	53.6		12.9		14486
6-18-08	77	61	46	62.1	1.27	53.6	0.40	12.9	Sec'd week	12005
6-19-08	76	60	44	61.6	1.56	51.2	0.17	20.7	%	13165
6-20-08	80	57	42	61.8	1.33	51.8		12.7		11554
6-21-08	76	58	46					12.7		13102
				Av	1.4			Av	7.4	

* Calculated for 36° Bé. nitric acid and 50° Bé sulphuric acid

produced 2,900 to 3,000 kgrms. 50° Bé sulphuric acid in twenty-four hours, which amounts to one-eighth of the total production of the plant. When it is considered that only the weak end gases of the last chambers are condensed in the tower, the efficiency of 13.3

kgms. of 50° Bé acid per cu. ft. tower space is very high. The amount of nitric acid formerly required at the Kunigundenhütte was reduced from 1.9% to 1.1%, and at the "Lazyhütte" near Benthien, Germany, the decrease amounted to 25%. The Tables IIIa and IIIb taken from the plant at Seaton-Carew are also very characteristic as showing the saving of nitric acid which can be attained by the regulator. The working conditions were exactly alike during the tests made in different plants, except that different methods for bringing the gases in contact with the acid were used.

TABLE III B

Date	Temperature of ° C.			Nitrose at 15° C.†		Chamber Regulator at 15° C.		Grams Total SO ₂ in 1 cbm. End gas‡	H ₂ O ₂ Con- sumption	Blende Used Kgms.
	1	2	3	° Be.	Con- tents.	° Be.	Con- tents.			
8-10-08	72	49	31	61.4	2.44	57.4	3.61	1.2		10765
8-11-08	70	50	30	61.6	2.22	57.4	5.56	1.2	First	14285
8-12-08	71	46	29	61.4	2.02	57.7	4.84	0.9	week	11672
8-13-08	73	53	33	61.6	1.89	57.7	3.90	0.9	0 7	11677
8-14-08	71	55	36	61.1	1.89	57.7	3.90	0.9		12603
8-15-08	73	55	39	61.4	2.64	57.1	5.29	1.5		11055
8-16-08	72	56	35							11459
8-17-08	75	54	37	61.4	2.22	56.3	3.61	1.2		12483
8-18-08	75	55	34	60.6	1.70	56.3	3.73	2.6	Sec'd	13300
8-19-08	71	50	35	61.4	1.70	56.3	3.73	2.6	week	10883
8-20-08	73	58	42	61.4	2.17	56.3	3.61	1.3		13555
8-21-08	78	57	36	60.6	3.17	56.3	3.61	3.0		12238
8-22-08	76	55	33	60.0	3.34	56.0	3.90	2.8		10707
8-23-08	78	52		61.6						12177

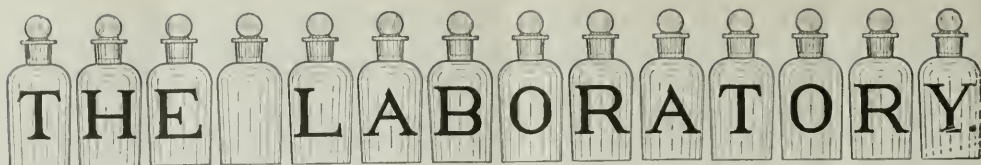
† Average nitrosé contents 2.3

‡ Average SO_3 contents in end gases 1.7 grms. per cubm

* Calculated for 36° Be. nitric acid and 50° Be. sulphuric acid.

The increase in the production of sulphuric acid in the chambers is caused not only in the last chamber but also the other chambers give a higher yield, on account of the possibility of using a stronger gas current. An average increase of 20% of the total production was attained at the Lazyhütte, in a run of several years. At the Kunigundenhütte the gain in production due to the chamber regulator was not determined, as the Gay-Lussac space was increased at the same time as the regulator was installed, but the total production per cu. ft. of space was doubled without enlarging the chamber. Thus the production amounted to 2.7 kgrms. of 50° Bé acid per cu. ft. of working space. The same result was obtained in the previously mentioned plant in North Germany. It was not possible to determine the gain in production due to the chamber regulator either in this plant or at the Central Acid Company as such a test would necessitate the idleness of apparatus used for the regular routine work of the plant. However, it is expected that such data will be obtained shortly from plants which are about to install the chamber regulator.

The attainment of a stronger chamber acid is due to the fact that less water or steam is required in the last chamber as the sulphur dioxide of the end gases is taken up by the acid of the chamber regulator, which is not true with the Gay-Lussac acid. As the acid of the last chamber gradually returns to the first chamber the whole product becomes stronger. At the "Lazy-hütte" the finished acid of the first chamber was thus kept at 54½ to 55° Bé without showing even a trace of nitrose.



COMMENTS ON VOLHARD'S VOLUMETRIC METHOD FOR COPPER.¹

BY DR. H. THEODOR.

For several years I have been using almost exclusively Volhard's method for copper titration with potassium sulphocyanate. I am informed by other chemists that this method is used comparatively seldom and that the electrolytic method and the iodine method are the most popular. Notwithstanding these facts, Volhard's method is to be preferred to the others for certain purposes; to the former for economical reasons, as there is no expensive apparatus required, which is quite a consideration in commercial laboratories, where it often happens that slack times will change with times of excessive work, and in order to keep in accordance with the latter it is necessary to be equipped with a large amount of apparatus which would be of little value in slack times. It is to be preferred to the iodine method because of the stability of the potassium sulphocyanate solution (while the thio-sulphate solution changes the titer steadily and must therefore be standardized daily), and also for the following reason: Copper ashes contain large amounts of iron, which occasionally exceed largely the amount of copper. If the iodine method is used, it is necessary to precipitate twice with ammonia, and if very large quantities of iron are present, a quantitative separation is not even then obtained, while with Volhard's method this difficulty is eliminated and thereby much time is saved. The accuracy of the method is high, if exact volumetric apparatus are used. The standardization of the sulphocyanate solution is made against a tenth normal silver nitrate solution, prepared from recrystallized silver nitrate, to which are added 50 cc. of nitric acid (sp. gr. 1.40) and diluted to one liter. It is still better to use C. P. silver and dissolve in an excess of nitric acid. As the titration is made in an acid solution, this excess of acid does no harm; and it keeps the burettes always absolutely clean. I prepare the sulphocyanate solution by dissolving about 14 grams of potassium sulphocyanate, free from chlorine, in one liter. As this compound is very seldom dry, such a solution is usually 0.15 to 0.17 normal, and is then of such a strength that about 10 cc. are required to precipitate 0.1 gram copper.

The standardization against the silver solution is accurate within 0.05 to 0.1 per cent. The solution is checked with purest electrolytic copper. It is best to dissolve 0.636 grams in a 250 cc. graduated flask in nitric acid, make the solution slightly alkaline with

ammonia, again neutralized with sulphuric acid and acidify; 75 to 80 cc. of the sulphocyanate solution, sodium sulphite solution and a few more drops of dilute sulphuric acid are now added until the solution smells strongly of sulphur dioxide. Then it is heated to 60° C., cooled and filled up to the graduation mark. To 100 cc. of the clear filtrate, ferric sulphate and very dilute nitric acid are added and the titration is made partially, i. e., first 50 cc. are titrated and then the other 50 cc. In this manner a better control of the titration is obtained and the "reading error" is reduced one-half. The use of sodium sulphite, which, of course, as well as the nitric acid and the ferric sulphate, must be free from chlorine, is to be preferred to sulphur dioxide solution on account of being odorless and because of the saving of volume. Under these conditions, the theoretical copper value of the sulphocyanate solution (equal to the silver value) has been without exception between 0.998 and 1.002, while the control determinations, after taking all precautions, check with each other to within 0.1 per cent.

For the analysis an aliquot portion of the nitric or sulphuric acid solution of the respective material is taken, and neutralized with strong ammonia, and then slightly acidified with dilute sulphuric acid; a little more than the calculated amount of potassium sulphocyanate solution is added, then sodium bisulphite, etc., as above. The excess of potassium sulphocyanate should not be too small. For about 50 cc. of the filtrate, about 3 to 5 cc. tenth normal silver solution should be required for retitrating. If the excess is too small, especially if it is below 1 cc. silver solution required for 50 cc. of the filtrate, copper can be often detected in a portion of the filtrate by testing with potassium ferrocyanide. Even if large quantities of iron are present, potassium ferrocyanide will only cause a light green precipitate with the filtrate, if all the copper was precipitated by the sulphocyanate solution, while in the other case a bluish gray precipitate is formed.

If the original solution contains large amounts of chlorine, it is necessary to evaporate to fumes with a few cc. of concentrated sulphuric acid; but it is not necessary to evaporate to dryness. If the amount of chlorine is only small, a correction can be made by adding tenth normal silver nitrate solution to an aliquot portion of the solution and retitrating the excess with sulphocyanate solution. Of course a sharp end point is often very hard to obtain in this titration. In most cases, ashes contain only traces of chlorine, which can be neglected. If the amount of chlorine is larger it is best to evaporate to fumes as above. The

¹Translated from *Chemiker-Zeitung*.

copper determination can be combined very satisfactorily with Brunck's nickel determination, as the filtrate of the copper sulphocyanate is very well qualified for the precipitation with dimethylglyoxime; if necessary a few grams of tartaric acid may be added. The sulphocyanate method can not be used if the haloids or silver or mercury are present.

In technical alloys and residues such ingredients will be found only very seldom. Perhaps mercury may be found occasionally in white metals. If silver is present, the method can be modified by precipitating with hydrochloric acid and evaporating the filtrate with sulphuric acid. All other metals which are met with in technical practice do no harm. For instance, if the method is applied to a solution containing lead, even large quantities of this metal would be of no consequence. If, after neutralizing with ammonia, sulphuric acid is added again, the bulk of the lead will be precipitated as lead sulphate. If nitric acid is used, the copper result may be found a little too high.

In conclusion, I wish to make a few comments on the "sand correction." Frequently in dissolving ashes, if pieces of slag are present, a solution is obtained which is difficult to filter. Of course, the solution could be made up to a certain volume and an aliquot portion taken, either by filtering the required amount through a folded filter or by directly pipetting the fairly clear solution after settling, but it would require many hours to filter and wash the insoluble matter. As large assay charges have to be taken to obtain a good average sample, the insoluble residue must be taken into consideration. I usually make, therefore, a correction by deducting 1% of the copper value found for each 10 grams of material, in 250 cc. of solution, for ashes running up to 20% copper, and 12% from the actual copper contents for ashes running over 20% copper. This rule is deduced from the following calculation: If the material were perfectly soluble, no correction would be necessary; on the other hand, if the copper were present as pure metal, without foreign admixtures, and the residue pure sand, the correction for each 10 grams in 250 cc. solution could be easily calculated from the specific gravity of sand (2.65 on an average).

TABLE I.

% Cu.	grams.		Relative	Absolute
found.	sand.	cc.	percentage	percentage.
10	9	3.40	1.35	.14
20	8	3.00	1.20	.24
30	7	2.65	1.05	.32
40	6	2.65	.90	.36
50	5	1.90	.75	.38
60	4	1.50	.60	.36

I have purposely carried out this calculation so far to show that .38 is the maximum correction. In practice, residues of alloys such as brass or red metals are mostly considered with an average copper contents of 70%. They usually contain some iron, decomposed slag, etc., so that the copper found represents about

two-thirds of all the dissolved ingredients. In this case the proportions are as follows:

TABLE II.

% Cu.	grams.		Relative	Absolute
found.	sand.	c.c.	percentage.	percentage.
5	9.5	3.50	1.40	.07
10	8.5	3.20	1.30	.13
20	7	2.65	1.05	.21
30	5.5	2.10	.85	.26
40	4	1.50	.60	.24
50	2.5	.95	.40	.20

In case the copper only represented one-half of all the dissolved substance, the last column (absolute percentage) would become as follows: .07; .12; .18; .12; none. This shows that the above formula for the correction comes, on an average, close to a few hundredths of 1% to the practical conditions.

This paper is not intended to bring out anything specially new, but to prove the value of Volhard's method, which I have used for over a thousand analyses. An exact analysis of drillings can be made in one to two hours, and of residues in two to four hours.

At the last convention of the National Electric Light Association in Chicago great interest was taken in the practical demonstration of the tungsten incandescent lamp, which has a higher light efficiency than the ordinary carbon lamp and is far more economical.

The lamp with the tungsten filament gives a brilliant white light, and when using 110 volts has a candle power of 150. The tungsten filament, if properly made, will not blacken the globe, an advantage which cannot be claimed for carbon lamps.

The market value of tungsten has been discounted somewhat during the past few months for the purpose of increasing the demand. At present ore containing 60 per cent tungstic acid is worth \$5.50 to \$6 per unit, or \$330 to \$360 per ton, f. o. b. Denver. Much larger supply of tungsten in this country is mined in Boulder county, Colo., although commercial deposits have also been opened in California, Arizona and elsewhere.

Should the electric light experts succeed in their propaganda for the tungsten lamp, we may expect to see the new light adopted by many municipalities and householders who are accustomed to use gas. As a natural result there will arise an increased demand for tungsten which will benefit miners everywhere. —*Mining World*.

Robert R. Abbott, of the Case School of Applied Science, Cleveland, O., advises the use of ammonium persulphate for etching copper for microscopic work. The specimen, after polishing and washing, is placed in a dish of boiling water, and enough persulphate is added to make about a 10 per cent solution. The boiling is continued until the crystalline structure is shown which usually requires from one to 10 seconds.

METALLURGY

SOME EXPERIMENTS ON THE CASE HARDENING OF STEEL BY GASES.*†

By JOHN C. OLSEN and JOHN S. WEIFFENBACK.

As is well known, for many purposes it is found convenient to use steel having a soft core and a very hard outer layer or case, the hardness of the material being dependent upon the presence of carbon in greater or less amount which is held in solution as a result of a process of annealing. If the steel contains a small amount of carbon in the core and a larger amount in the outer layer the process of annealing will produce a hard case and leave the core soft and tough. The older methods of case hardening consisted of heating the iron in contact with a great variety of solid material invariably containing carbon in large amount, and in smaller amount, nitrogen, and at times alkaline substances. Charred organic material was usually used such as wood charcoal or burnt leather; the latter being advantageous because of its high nitrogen content. Such charred organic matter is invariably alkaline from the decomposition of the alkaline salts originally present in the vegetable fibers. Potassium cyanide has also been used. This salt contains the alkali carbon and nitrogen. As a result of heating iron in contact with material of this kind the iron absorbed more or less carbon depending upon the temperature to which the mixture was heated, the materials present and the length of time of the heating. Investigation has shown that the absorption of carbon is much more rapid from material containing nitrogen and further that this nitrogen must be in combination, free nitrogen having no influence on the process. After the proper amount of carbon had been absorbed the sample was annealed by heating to the proper temperature and plunging into cold water or oil.

Recently the use of gases instead of the solid carbonaceous material has been introduced, and processes of this kind are used commercially to-day. We can find no published record of experiments conducted to ascertain the relative efficiencies of the various carbon gases. This investigation was undertaken to study this question and also to ascertain what chemical reactions take place when the carbon from a given gas enters the steel. The temperature at which the case hardening must be carried out has been pretty closely determined by previous workers, i. e., from about 700° to 900° C., or 1,300 to 1,700° F. It has also been ascertained that if the case hardening is carried out with gases subjected to a certain amount of pressure

the action is much more rapid. This was to be expected, inasmuch as the carbonaceous material is in this manner concentrated in the vicinity of the surface of the steel, that being the only place where action can take place. We have used in our experiments the following gases: Illuminating gas, as supplied in Brooklyn by the gas companies; methane, carbon monoxide and acetylene. The illuminating gas of Brooklyn contains on the average about 26% of carbon monoxide, the same per cent of hydrogen and methane, about 12% of "illuminants" consisting of ethylene, acetylene and benzene and smaller proportions of free nitrogen, oxygen, carbon dioxide, etc. The acetylene was that used in automobiles for lighting purposes. As 68.5% of the gas was absorbed by bromine it was considered sufficiently pure. The other gases were made in the laboratory and were very nearly pure. The carbon monoxide was made by decomposing oxalic acid with sulphuric acid and absorbing the carbon dioxide by means of strong caustic potash solution. The methane was made by heating a mixture of sodium acetate and soda lime in a copper retort. Experiments were carried out with each gas alone and mixed with a definite amount of ammonia gas. The ammonia gas was mixed with the carbon gas by bubbling the latter through Wolff bottles containing an aqueous ammonia of definite strength. The amount of ammonia introduced into the gas was ascertained by allowing a liter to pass through a definite amount of standard sulphuric and titrating back to excess of acid with standard alkali. The per cent of ammonia gas was then calculated. Three strengths of ammonia were used, as follows: (a) 125 cc. of 28.5% ammonia with 875 cc of water; (b) 250 cc of the strong ammonia with 750 cc of water, giving (b) double the strength of (a); (c) 500 cc of strong ammonia and 500 cc of water, giving ammonia twice the strength of (b) and four times the strength of (a).

It was found that when gas was bubbled through the weakest ammonia (a) it contained 2.28% of ammonia gas. When bubbled through (b) it contained 4.8% while with (c) 11.4% of ammonia gas was found in the resulting mixture.

Experiments were first carried out with the illuminating gas, to ascertain if the ammonia would combine with the carbon monoxide or other carbon gas present to form cyanides or cyanogen, it being thought that the following reaction might take place:



For this purpose the mixture of ammonia and illuminating gas was passed through a glass tube which was heated in a combustion furnace to the case harden-

*Read at the Brooklyn meeting of the American Institute of Chemical Engineers and presented for publication in the Transactions of the Institute.

†The authors are under obligation to the American Gas Fuel and Chemical Co. for the use of one of their furnaces for this investigation.

ing temperature, 800 degrees Centigrade or 1500 degrees F. The temperature was measured by means of Seger Cones and pieces of potassium and sodium chloride. The sodium chloride melts at 804 degrees Centigrade. The potassium chloride melts at 772 degrees Centigrade. Seger Cone No. 17 was used.

The mixed gas after passing through this tube was allowed to bubble through caustic soda solution and cyanides were tested for by the well known and very delicate Prussian blue test, ferric and ferrous iron being added and the solution then acidified with hydrochloric acid. No test whatever for cyanides was obtained. It was thought that cyanides might be formed in the combustion tube and then decomposed so that no test would be obtained in the caustic soda solution. Another experiment was therefore made to ascertain if hydrocyanic acid could exist at the temperature of the glass tube. For this purpose a flask containing a small amount of potassium cyanide and a little sulphuric acid was introduced so that the gas bubbled through this flask before entering the heated glass tube. A test made for cyanides on this gas on leaving the hot glass tube gave a very excellent test of cyanides. It was concluded, therefore that the ammonia did not react with the constituents of illuminating gas to produce cyanides. We have not ascertained how ammonia assists in the case hardening process.

We next conducted an experiment to ascertain what portion, if any, of the ammonia was decomposed when the mixed gases were heated to the annealing temperature.

For this purpose the illuminating gas mixed with ammonia from solution (a), (b) and (c) was passed through the hot glass tube.

Experiment	Amt. of NH_3 gas per liter used in experiment	Amt. of NH_3 gas per liter after being heated to 1500° F.	Amt. of NH_3 gas per liter by heating to 1500° F.
IV (a)	22 cc.	19.8 cc.	2.2 cc.
IV ₂ (b)	48.4 cc.	22.0 cc.	26.4 cc.
IV (c)	114.4 cc.	70.4 cc.	44.0 cc.

The actual case hardening experiments were carried out on samples of soft Norwegian iron containing only .08% of carbon. This iron was purchased in rods 1 cm. in diameter which were cut up into 6 inch lengths. A common gas pipe was used for the case hardening. It was heated in an ordinary combustion furnace the temperature of 1500° F. being maintained throughout the experiment. The per cent of carbon in the iron both before and after case hardening was determined by dissolving the iron in cupric potassium chloride and oxidizing the undissolved carbon by means of chromic anhydride and sulphuric acid absorbing the resulting carbon dioxide in caustic potash and weighing. The samples for analysis were obtained by turning off the outer layer of metal on the rod in a lathe. On many of the samples this was impossible on the annealed and hardened sample, but on

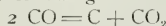
drawing the temper it was found a simple matter to obtain samples. The depth to which the carbon penetrated was obtained by breaking the rod and measuring the hard case by means of a microscope fitted with an ocular micrometer.

SUMMARY OF EXPERIMENTS V TO XVII.

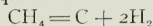
Experiment.	Gas used.	Hardness.	Depth of case.	Carbon composition.
V. Illuminating.				
	NH_4OH (a)	4 glass	.1 m.m.	.57%
VI. Illum.				
	NH_4OH (b)	4 glass	2/30 m.m.	.665%
VII. Illum.				
	NH_4OH (c)	4 glass	2/30 m.m.	.915%
VIII. Illum.		4 none	none	none
IX. Illum.				
	NH_4OH (a)	8 glass	3/10 m.m.	1.12%
X. Illum.				
	NH_4OH (b)	8 glass	3/10 m.m.	1.16%
XI. Illum.				
	NH_4OH (c)	8 glass	3/10 m.m.	1.15%
XII. CO				
	NH_4OH (c)	4 glass	4/10 m.m.	1.45%
XIII. CO		4 glass	4/10 m.m.	1.36%
XIV. CH_4		little	not well	
	NH_4OH (c)	4 hardness	defined	.32%
		little	not well	
XV. CH_4		4 hardness	defined	.26%
XVI. C_2H_2				
	NH_4OH (c)	4 glass	3/10 m.m.	.98%
		little	not well	
XVII. C_2H_2		4 hardness	defined	.41%

It is evident that ammonia gas facilitates the case hardening in all cases except that of carbon monoxide which seems to act almost as well without as with ammonia. Of the three gases studied the carbonizing ability is in the following order: Carbon monoxide, acetylene, methane. Carbon monoxide therefore is by far the best gas for this purpose, as no ammonia seems necessary and it gives the best penetration in the same time.

A few experiments were carried out to ascertain the chemical reactions taking place during the carbonizing. In the case of carbon monoxide the gas was freed from carbon dioxide by bubbling through strong caustic potash solution before entering the case hardening tubs. On emerging from this tube a considerable amount of carbon dioxide was found present. The carbon monoxide must therefore break up according to the following reaction:

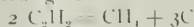


With methane the reactions take place according to the following equation:

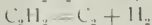


This was ascertained by analyzing the gas emerging from the case hardening tube by mixing with air and passing over palladium sponge, 9.45% of hydrogen being found.

The acetylene gas apparently breaks up during carbonization, according to two reactions:



and



This was shown by the fact that the gas after carbonization contained no acetylene at all, but contained a large amount of hydrogen and also methane. A large deposit of carbon was also found in the tube.

THE PYROMETRY OF THE BEEHIVE COKE OVEN.*

By J. R. CAMPBELL.

Chief Chemist, H. C. Frick Coke Co., Scottsdale, Pa.

The data recorded in this article has been taken from the ordinary beehive coke oven in the Connellsville region, the oven either burning through the trunnel head or into a waste heat flue. In taking the temperatures different devices were employed and their relative merits determined. A brief description of the apparatus may not be out of order.

As a standard instrument a form of thermo-electric pyrometer was chosen. Without doubt this is the most accurate apparatus yet devised for measuring and recording high temperatures but it has its limitations and is open to objections in practical usage.

An attempt was made to use the short thermo-electric couple, devised by Mr. Bristol, but the long couple was found to be more satisfactory, though more expensive. A six foot fire end was found to be most convenient for taking coke oven temperatures. The platinum and platinum-rhodium wire of the couple was insulated by means of small porcelain tubes and then were enclosed in a cast iron pipe, the end of the couple being protected by a porcelain and clay covering. For further protection a shorter piece of cast iron pipe was slipped over the pipe running the length of the couple. The iron pipes stand handling better than porcelain, and of course are easily renewed when burnt up. The limit of temperature which such a fire end can withstand is about 2,900 degrees F., which temperature is rarely exceeded in coke ovens of the Connellsville region.

Among the many other devices on the market for the observation of high temperatures, Wanner's optical pyrometer will commend itself to every practical man for the simplicity of construction, ease and rapidity of manipulation and accuracy of results. Some of the temperatures given below were made with this instrument and the writer considers them very reliable.

The principle of this pyrometer is the same as that of the various older forms, that is, the comparison of the quantity of light emanating from the heated mass to be measured, with a constant source of light. An osmium lamp of the necessary voltage is used as the standard light. Looking through the pyrometer, a circle of light appears, divided into distinct halves of different intensities of light. By turning an adjust-

ment on the pyrometer these two halves can be made to appear alike or matched as it were. Then the temperature is easily read from the scale on the adjustment with the aid of a table. This type of pyrometer must be standardized at least once a day against an amylacetate lamp flame after which the osmium lamp is regulated by a resistance which is switched into the lamp circuit.

The personal equation of course is a factor in the operation of an optical pyrometer, but the writer has no hesitancy in recommending it in commercial work. A careful observer with unimpaired vision will get excellent results. However, one cannot examine particular points in a coke oven as with a thermo-couple. The results obtained by these two types of pyrometers have always agreed in the oven work, and the writer has seen many observations by each.

Among the other means of taking the temperatures of coke ovens, the remaining most important one is by means of the Seger cone. This method is familiar to every one, hence need not be detailed here. In this connection it need only be noted that the melting points of the silicate mixtures which compose the Seger cone do not correspond with exactness to definite temperatures, because the fusion of any complex substance is not wholly a matter of temperature. It depends upon the rate at which the heat is applied, the fineness of the grain of the mixture, the chemical conditions of the heating process, etc.

TEMPERATURE OF BEEHIVE OVEN DURING COKING PROCESS.

2110 deg. F.	— 3 hr.
2285 deg. F.	— 6 hr.
2460 deg. F.	— 9 hr.
2490 deg. F.	— 12 hr.
2600 deg. F.	— 15 hr.
2765 deg. F.	— 18 hr.
2560 deg. F.	— 21 hr.
2660 deg. F.	— 24 hr.
2800 deg. F.	— 27 hr.
2725 deg. F.	— 30 hr.
2725 deg. F.	— 33 hr.
2660 deg. F.	— 36 hr.
2560 deg. F.	— 39 hr.
2490 deg. F.	— 42 hr.
2370 deg. F.	— 45 hr.

— — —
Average 2555 deg. F.

This was a 48 hr. charge burning normally in a 12 ft by 6 in. beehive coke oven. The test was taken on a plant which used the waste heat of the oven for operating the boiler plant, by means of the familiar short flue connecting the oven to a main waste heat flue which led under the boilers.* These figures may be considered as a fair average. For the purpose of this article, the readings are assumed to be taken every three hours. As a matter of fact the first reading was taken after the charge was burning freely and the

*This article is supplementary to Mr. Campbell's paper on "The Beehive Coke Oven as a Power Plant," appearing in The Chemical Engineer (IX, 6, p. 178).

*See Chem. Eng. ix, 6, p. 179.

last just before the oven was watered. The main object is to show the variation of the temperature during the coking process.

One interesting thing to note is the fall in temperature about the 21st hour of the coking process. This was caused by the "watering out" of the oven next to the one under test. It will also be noted that the maximum temperature of 2800 degrees is attained when the coking process is about half completed and the minimum is at the beginning of the coking process; also, that the temperature at the close is slightly greater than at the beginning.

These conditions could almost be formulated into a universal law. It is understood that in particular instances higher temperatures than the 2800 degrees have been obtained. The beehive coke oven from which the waste heat is utilized may burn hotter than the same oven burning into the air. This is due to the increased draught on the flue oven.

We have probably approached the highest temperature practicable in coke making. The problem of refractories is already a serious one, both for the coke maker and the manufacturer of oven brick. The operator of coke ovens has been led to devise all kinds of schemes to get away from the evil effects of this intense heat and falling flues and ovens. One of these is an air-cooled, overhead connecting flue instead of the regulation short flue, but this means a sacrifice of heat, or power to the boiler plant. This point is illustrated by the following pyrometric readings:

Regulation short flue.....2650 deg. F.

Air-cooled overhead flue.....2300 deg. F.

These tests were made on a 48 hr. charge after the oven had been burning normally for about 18 hrs. There is a dissipation of 350 degrees F. which means power to the boiler plant.

It has been noted that the waste heat gases are conducted under the boilers, where the temperature is approximately 2000 degrees F. When we figure that the average temperature of the beehive flue oven is 2550 degrees, here again comes a heavy loss of heat and power. This no doubt is caused by radiation and would be hard to overcome.

TEMPERATURE IN BEEHIVE COKE OVENS AT VARIOUS POINTS.

Kind of Oven.	Kind. Charge.	Time Burnt.	Point where temperature was taken.	Deg. F.
Bank Beehive	48 hrs.	24 hrs.	Front of oven directly inside of arch.....	1600
Bank Beehive	48 hrs.	24 hrs.	Top of charge 4' 0" inside of arch.....	1850
Bank Beehive	48 hrs.	24 hrs.	Crown of oven 3' 0" below trunnel.....	2350
Bank Beehive	48 hrs.	33 hrs.	Front of oven directly inside of arch.....	1525
Bank Beehive	48 hrs.	33 hrs.	Top of charge 4' 0" inside of arch.....	1950
Bank Beehive	48 hrs.	33 hrs.	Crown of oven 3' 0" below trunnel.....	2250
8 ft. Rect.	48 hrs.	30 hrs.	Front of oven directly inside of arch.....	1925
8 ft. Rect.	48 hrs.	30 hrs.	Crown of oven 3' 0" below trunnel.....	2050
6 ft. Rect.	48 hrs.	26 hrs.	Front of oven directly inside of arch.....	1800
6 ft. Rect.	48 hrs.	26 hrs.	Crown of oven 3' 0" below trunnel.....	2150
Block Beehive	48 hrs.	30 hrs.	Front of oven directly inside of arch.....	1550
Block Beehive	48 hrs.	30 hrs.	Top of charge 4' 0" inside of arch.....	1925
Block Beehive	48 hrs.	30 hrs.	Crown of oven 3' 0" below trunnel.....	2500

Block Beehive	48 hrs.	30 hrs.	Intersection outside of arch with front wall.....	800 to 1000
Bank Beehive	72 hrs.	0 hrs.	Bottom of oven under tile at center of oven.....	500
Bank Beehive	72 hrs.	72 hrs.	At point midway between trunnels and over arch.....	1325
Bank Beehive	72 hrs.	72 hrs.	Max. temp. inside of trunnel.....	2500
Bank Beehive	72 hrs.	72 hrs.	Bot. of oven under tile at center of oven.....	1100
Bank Beehive	72 hrs.	72 hrs.	Bot. of oven—top of tile—after 16 min. watering.....	150

The tabulation is interesting in that it shows the temperature of special points in a coke oven. The cold air entering the oven over the door naturally lowers the temperature at this point. Also it is a natural conclusion that the hottest part of a coke oven is not on top of the charge but higher up in the combustion chamber. All the temperatures given were obtained from an oven burning into the air.

The writer draws the following conclusions, based upon his experience in connection with the various types of ovens and localities in the Connellsville region.

Maximum Temperature Attained in—

1. Small type of beehive oven and low volatile matter (comparatively) 2200 deg. to 2400 deg. F.
2. Large type of beehive oven and high volatile matter (comparatively) 2400 deg. to 2600 deg. F.
3. Large type of beehive oven and high volatile matter (comparatively) with flue system for operating boiler plant 2700 deg. to 2900 deg. F.

From which we deduce (a) that a low grade refractory will serve its purpose in No. 1, hence the longevity of this type of oven; (b) that this same material used in No. 2, fails of its purpose, hence come the many and manifold troubles of the present coke oven builder and operator, caused by falling ovens; (c) that only the highest grade refractory will stand the heat of No. 3.

STANDARDIZING FOUNDRY FACINGS.*

By H. F. FROHMAN,
Cincinnati, Ohio.

Standardizing every article of manufacture and every commodity seems to be the order of the day. This not only applies to the iron and steel industry so far as its finished products are concerned, but to every article that enters into the manufacture of these products. The foundry is also sharing this tendency of the times, and to the writer has been assigned the problem of suggesting standards for the more common varieties of foundry facings in use today.

Most every foundry, whether producing large or small work must use sea coal or bituminous facing. This is a ground coal mixed with the sand to prevent it from fusing together and at the same time peel the casting.

This sea coal facing must be high in volatile matter, low in ash and sulphur. It must be known as a gas coal, and the most suitable coal for this purpose should show approximately the following analysis:

Moisture	1.40
Volatile matter	37.66
Fixed carbon	54.44

*Read at the meeting of the American Foundrymen's Association, Cincinnati, O., May 18-20, 1909.

Ash	5.86
Sulphur	0.64

Relative to coke blacking used on certain classes of work, this should analyze:

Fixed carbon	88.0
Ash	9.0
Sulphur	0.8

Anthracite blacking when used as a pipe blacking or mineral facing should show:

Moisture	7.0
Fixed carbon	84.0
Ash	9.0
Sulphur	0.5

A good grade of charcoal facing which is generally used by the foundries, not only for parting purposes, but also for foundry facing and as a core wash, should analyze:

Volatile matter	10.0
Fixed carbon	85.8
Ash	3.7

Ash varying according to the kind of wood and time of cutting.

In judging a foundry facing such as graphite, coke, anthracite, charcoal, the carbon percentage should conform as near as possible to the above.

Not only should this coal show high in volatile matter and fixed carbon, but very low in ash and sulphur, but also this coal must be ground to practically the same consistency as the moulding sand used for the castings.

In other words, for heavy work a rather coarse sand is used and the sea coal used for this purpose should all pass through a No. 14 mesh. For general or medium sized work, the sand of course being finer, it would require a finer ground sea coal facing, and this all to go through a No. 18 mesh.

For small castings such as stove plate and radiator work, naturally requiring a very fine and rather close sand, it requires a sea coal facing in accordance therewith, and all of this sea coal facing should pass through a No. 32 mesh.

Sea coal facing is used to mix with the sand to peel the castings, proportions running from 1 part of sea coal facing to 10 to 30 of sand, depending upon the size of the castings.

There has also been suggested that a good grade of sea coal facing with high percentage of volatile matter, when the hot iron comes in contact with the mold, forms a gas or cushion, so that the molten iron does not come in thorough contact with the molding sand.

As stated, this may be merely a theory, as it has not been absolutely determined what real action takes place when the molten metal comes in contact with the mold, and makes this separation.

In our experiments, we have molded brake shoes, using the same sands under the same conditions, mixing the sand 20 to 1 with the following: (1) sea coal,

(2) Ceylon plumbago, (3) charcoal, (4) anthracite, (5) sawdust. All of these different materials ground to the same fineness as sea coal facing. The only good castings produced where the iron did not burn into the sand, was the mold made with sea coal facing. The Ceylon plumbago experiment indicates that it is not the separation of the sand particles by a medium preventing fusion. Sawdust contains more volatile matter than sea coal, but would not peel the casting. This disproves the cushion theory. The formation and following deposition of certain hydro carbons, yielding carbon which peel the casting, may furnish a more plausible explanation.

This theory does not question or exclude the beneficial effect of sea coal as a venting medium, nor its influence in preventing a fusion of the sand by the separation of sand particles.

PLUMBAGO.

In making castings, especially medium and large size, something is required to face the mold; that is by facing the mold, I mean covering the pores of the sand, so that the mold will practically have a smooth surface.

The very best article for this purpose is plumbago or graphite with a high percentage of graphite carbon. The crystalline form from Ceylon giving the best results. This plumbago must contain a certain percentage of graphite carbon so that when the molten iron is poured into the mold, it will assist the iron to find its proper resting place, and be of such a refractory nature that the iron cannot cut into the mold itself.

A good plumbago or blacking must not only have the proper chemical analysis, be of such a refractory nature to withstand the hot iron from cutting into the mold, but also be of such a nature that it will not retard the flow of the molten metal, but on the contrary, assist it to glide along.

Ceylon graphite (high grade for facing purposes), should analyze about as follows:

Moisture	1.20
Oxide of Iron	5.90
Aluminum	3.06
Lime	0.90
Silica	16.14
Graphitic carbon	72.80

The bulk of Ceylon graphite imported for foundry facings runs between 50% and 60% graphitic carbon. These are straight Ceylon graphites, not touched by the facing man. In the face of this fact an amusing instance may be mentioned here. We had made a shipment of straight Ceylon graphite showing 62% graphitic carbon to an eastern firm; their chemist was of the opinion that all Ceylon graphites analyzed 100% graphitic carbon. With great care he figured out to the third decimal how much of an inferior article we had added to the Ceylon plumbago, and we "got it."

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

HENRY WYSOR, Metallurgical Editor.

PUBLISHED MONTHLY BY

THE CHEMICAL ENGINEER PUBLISHING COMPANY

355 Dearborn Street, Chicago

Entered as Second Class Matter, Aug. 19, 1907, at the Post Office at Chicago, Illinois, March 3, 1879.

Subscription—United States, Cuba and Mexico . . . \$2.00
Extra postage to Canada 25c a year; to foreign countries 50c a year.
Remittances may be made by check, draft, or money order in favor of
THE CHEMICAL ENGINEER PUBLISHING CO.

All matter connected with subscriptions or advertising should be sent to
THE CHEMICAL ENGINEER PUBLISHING CO., 355 Dearborn street, Chicago.
Anything intended for the Editorial Department should be sent directly
to the Editor, Richard K. Meade, Nazareth, Pa.

NOTES AND COMMENTS.

Potash Syndicate.

Press dispatches from Berlin, dated July 23rd, state positively that the potash syndicate will not be renewed. At the meeting which ended shortly before midnight of the day before, the difference of opinion between the several interests was so great that Herr Paxmann, the government's leading mining expert, who presided at the meeting, said that a continuance of the negotiation was useless. Herr Schmittmann, the sole proprietor of the Ascherleben mine, said he was ready to attempt to reach an agreement regarding his American contracts, but that to do this would take much time.

A motion was then put proposing to prolong the syndicate until September 25th, but this motion was rejected. The president of the syndicate invited the members to meet later, when an effort would be made to form another syndicate.

Unquestionably the American pressure and financial support given to the opposers were the cause of the failure of the syndicate to be renewed.

The Status of the Engineer.

In the annual address of the president of the American Society of Civil Engineers, Mr. Onward Bates discusses to considerable length the status of the engineer. What Mr. Bates has to say of the civil engineer is largely applicable to the chemical engineer also. Mr. Bates' long experience as an engineer and contractor have led him to the conclusion that while the professional work of the civil engineer is now recognized as of the greatest importance, this recognition does not carry with it the social and financial consideration which are commensurate with his responsibility. In most callings and professions the chief positions are held by men who have executive ability, and while the engineer may have such a position, his work has necessarily kept him engaged chiefly in technical matters, thus depriving him of the advancement in public opinion and financial remuneration which comes only to masters of men. President Bates suggests a two-fold remedy: (1) That the engineer should mix more in public and social fields, and (2)

That engineers who rise to executive positions should use their influence wherever possible to give to their subordinates employed in mere technical positions as much public standing as the character of their work and responsibility warrant, and as great financial returns as is commensurate with their position.

Sulphuric Acid From Smelter Fumes.

The directors of the Tennessee Copper Company, Ducktown, Tenn., have decided upon the construction of another acid plant, which will more than double the sulphuric acid output of this concern. The plant now in operation has a capacity of 300,000 tons of acid annually and cost approximately \$1,000,000. In the erection of the new plant, however, the Tennessee Copper Company expects, by taking advantage of mistakes made in the construction of the first acid plant, to be able to build the new works at a cost of \$800,000. The Ducktown Copper, Sulphur and Iron Company also has a large plant for the manufacture of sulphuric acid from its smelter fumes under construction. Both companies make use of the chamber process. The contact process was tried by the latter of these concerns, but the experiment failed, and they commissioned one of the best chemical engineers of the country to build them a chamber process plant. Both of these concerns are located in the heart of the fertilizer industry and hence can find a ready market for their product. The effect of these mills has been to bring into the sulphur and pyrites trade a new element and a new competitor, and it seems probable that the majority of fertilizer factories will purchase their acid of the smelters rather than manufacture it themselves. A great many of these concerns have failed to lay in large supplies of sulphur and pyrites, preferring to watch the outcome of the acid plants at the smelters and believing that they would ultimately be able to obtain their acid from these latter much cheaper than they could make it themselves.

The German Cyanide Trust.

With the announcement of the failure of the German potash syndicate to be renewed, comes a communication in the *Daily Consular and Trade Reports* that the output of cyanide is now controlled by a Frankfort firm, and the following statement is made in regard to the condition of the cyanide industry in Germany:

"Publication on January 30 of a brief report from this consulate-general on the German cyanide trust having aroused the interest of American buyers of cyanide, it may serve some useful purpose to define more exactly the nature of this trust. The whole of the German output of cyanide, so far as can be learned, is controlled by the Deutsche Gold- und Silber-Scheideanstalt, of Frankfort, which has agreements with the various manufacturers to take over their product, or to compensate them in some manner for keeping out of the market. Five different firms, all mentioned in the report of January 30, practically

confirm the following written statement of one of their number:

"I should advise you to apply for information to the Deutsche Gold- und Silber-Scheideanstalt, in the hands of which, so far as we know, the sale of the production of all German cyanide makers is united."

"The concern mentioned has an American house, which controls the sale of German cyanide in the United States. Orders from Mexico are executed from Frankfort, and a Hamburg firm is the sole agent for Africa and Australia."

"From being a losing business, demoralized by low prices, the sale of cyanide has become a presumably profitable branch of the general business of the Deutsche Gold- und Silber-Scheideanstalt, which, on March 31, 1908, according to the published and freely circulated annual report, paid 30 per cent dividends on a capital of \$2,380,000, besides accumulating a reserve of \$1,856,400 and unpaid profits of \$238,000."

"The same report shows that the Frankfort company has relations with three American concerns, one of which sells its products in the United States, and it states that these companies, while suffering from a decrease in business, have been spared large direct losses, so that dividends as in the previous year could be paid."

"The report further shows that the Deutsche Gold- und Silber-Scheideanstalt has established, or in part supported, eight concerns in Austria, France, Germany and Switzerland."

"According to information from reliable Hamburg exporters, it has been impossible, since the organization of this trust, commonly described as the syndicate, to buy cyanide in the open market for export to the United States."

BOOK REVIEWS.

METALLIC ALLOYS. By G. H. Gulliver, Lecturer in Engineering in the University of Edinburgh. 20 x 15. xv + 254 pages. 104 illustrations. Cloth. London: Charles Griffin & Company, Limited. Philadelphia: J. B. Lippincott Company. 1908.

This book represents, in part, a course of lectures given by the author to engineering students at Edinburgh. It is the author's purpose to consider chiefly from the scientific point of view the structure and constitution of alloys. The work is based upon the researches of Sorby, Martens, Osmond, Stead, Roberts-Austen and others of like notoriety. To this is added later work including the author's own, which is extensive.

The first chapter is devoted to methods and apparatus used in the investigation of alloys. In Chapters II to VI a systematic and comprehensive study is made of the theory of solution, chemical equilibrium and chemical action as related to binary alloys and metallic mixtures. Chapter VII is devoted to the bronzes, brasses and steels, and Chapter VIII deals with alloys of more than two metals.

As would be expected the book is elementary in its nature though it contains more actual essential matter on the subjects undertaken than any other book of like size. The subject matter is nicely arranged, and wisdom is shown in the number and choice of illustrations. Some parts of the text might well have been given less prominence, while more attention might have been given to other phases of the subject, but this is only opinion. As a teacher's and student's handy manual this book is highly recommended.

CHEMICAL ANALYSIS OF SPECIAL STEELS, STEEL-MAKING ALLOYS AND GRAPHITES. By Charles Morris Johnson, Chief Chemist to the Park Steel Works of The Crucible Steel Company of America. 21x15. Cloth. VI. 221 pages. Price, \$3.00. New York: John Wiley & Sons. 1909.

The subject-matter is set forth under the following headings: Qualitative Tests for Chromium, Vanadium, Copper Titanium, Nickel, Molybdenum and Tungsten in Steel; Analysis of Vanadium Steel and Ferro-Vanadium; Analysis of Titanium Steel and Ferro-Titanium; Analysis of Tungsten Powders; Analysis of Tungsten Steel and Chrome-Tungsten Steel; Analysis of Low Per Cent. Tungsten Steel; Analysis of Molybdenum Powders; Analysis of Tungsten-Molybdenum Steels; Analysis of Ferro-Chrome, Chrome Ore and Carbonless Chrome; Determination of Aluminum in Steel; Determination of Copper in Steel and Pig Iron; Separation of Nickel and Copper from Iron and Vanadium by Potassium Ferri-cyanide; Determination of Copper in Metallic Copper; Rapid Determination of Nickel in the Presence of Chromium, Iron and Manganese; Analysis of Ferro-Manganese; Rapid Volumetric Method for Manganese in the Presence of Iron, Calcium and Magnesium; Determination of Carbon in Iron and Steel by Direct Ignition with Red Lead or Litharge; Determination of Carbon in Steel, Ferro-Alloys and Plumbago by Means of an Electric Combustion Furnace, Also by Gas and Blast; Carbon in Steel by Color; Phosphorus in Steel, Pig Iron, Bar Iron and Wash Metal; Sulphur in Steel, Bar Iron, Pig Iron and Wash Metal; Manganese in Special Steels, Bar Iron and Wash Metal; Silicon in Iron and Steel; Analysis of Graphite and Graphite Crucibles; The Annealing of Plain and Special Steels; Percentage Reduction of Acids; A Practical Automatic Steam Water Still; A Simple Laboratory Method for Making Clay Combustion Boats.

This little book should be appreciated as coming from the hands of a busy steel works chemist. Many of the methods given are variations from those in common use, being the product of the author's own experience. Some of these appear tedious and of questionable advantage, but all deserve careful test. In his method for the volumetric determination of nickel the author uses ammonium citrate to hold the iron in solution when the excess of ammonia is added

before the cyanide titration. He claims that satisfactory results will be obtained if the citrate is used in the quantity recommended. Failure in obtaining uniform results with the use of ammonium citrate in the presence of large amounts of iron and other metals has established a general disfavor of this method. Many chemists are now using sodium pyrophosphate, as suggested by Campbell and Arthur (Journal Amer. Chem. Soc., XXX, 7, p. 1116).

The chapters on the analysis of graphite and graphite crucibles and the annealing of steel are most interesting and instructive. It would appear that the microscope might be found useful in connection with the unique chemical test for annealing in steel. The statement that "rapid cooling of *perfectly* annealed steel has no effect whatever on its softness," allowing an annealing temperature of from 700 to 720 degrees C., is not supported by the proof that doubters will demand.

From a literary point of view the book merits criticism. The style is abrupt, and in some places the text is obscure. The poverty of our English may be blamed for the author's use of the word *anneal* as a noun. His loose manner of writing the names or symbols of the alloys of iron should be objected to, especially by chemists, abundant examples being found, such as "Ferro-V" and even "FeTi". This does not, however, detract from the value of the treatise in the hands of an experienced chemist. Whatever there may be to criticise or question, the author has freely given to the profession the benefit of his experience, and his work deserves the highest appreciation.

DIRECTORY OF PORTLAND CEMENT MANUFACTURERS,
TOGETHER WITH MANUFACTURERS OF GYPSUM AND
LIME. 32 mo. Limp Leather. 220 pages. Price \$1.00.
The Cement Era, Chicago, Ill., 1909.

This little book contains a list of the cement companies at the present time operating, under construction, or now being financed in this country and Canada. The location of the offices and works are given, the officials of the companies, the capitalization, the number of barrels manufactured per day and the number and length of kilns. In some cases, other manufacturing data are also included. This is followed by a list, alphabetically arranged, of the officers, the superintendents and chemists of the cement companies, with their addresses and the company with which they are associated. A list of the brands employed by the various cement companies is also given. This includes many labels printed in colors. The book concludes with a list of the gypsum companies and their officials and also a list of the lime companies, with, in some instances, their officials. The book is quite complete, and, as it is gotten out along the lines of the little directory first prepared by Mr. Bottomley, the former secretary of the Portland Cement Manufacturers' Association, it will prove very valuable to all those interested in Portland cement; either its manufacture or use.

INDUSTRIAL NOTES.

MERCK'S BLUE BOOK.

We have received from Messrs. Merck & Co., of New York, a copy of their catalogue of tested reagents. This little book is neatly gotten up, bound in blue, and printed on a shade lighter blue paper. It contains the prices of the various chemicals, both for one pound and $\frac{1}{4}$ pound bottles; while for the more expensive, the prices for smaller quantities are given. Together with the price is a statement showing for what impurities the reagent has been tested, and its freedom from these. The uses of the chemical in analytical work are also given.

Merck's reagents have all been submitted to the blank tests enumerated for each reagent in the price list, and are not put on the market unless they stand these tests. The price list has been so arranged that the purchaser can see at a glance whether the chemical may be used for the purpose which he wishes or not. All of Merck's reagents are tested by the methods described in "Chemical Reagents: Their Purity and Tests," a book written by E. Merck and published in 1907 by the D. Van Nostrand Co., of New York. This volume gives full details of the tests which were applied to Merck's reagents. A distinctive blue label is used on all Merck's tested reagents; this is done in order to help dealers and chemists to distinguish the reagents for analysis from Merck's technical chemicals. In ordering Merck's reagents, therefore, it is usually better to specify "Merck's Blue Label Reagents."

TWO NEW CATALOGUES.

Wilson-Maeulen Co., 1 East Forty-second street, New York, are distributing two attractive catalogues; one on "Quartz Chemical Apparatus," and the other of the "Alarm Indicator Pyrometers." Their quartz apparatus is of two kinds—transparent quartz and electroquartz. The former is made from rock crystal, while the latter is made from pure silica. With the transparent quartz all surfaces are perfectly glassy, and complex forms, such as retorts and distilling flasks, are made very symmetrical. Apparatus made from transparent quartz is only in laboratory sizes. The electroquartz, on the other hand, is translucent and may be used both for small and very large technical apparatus. In laboratory size, both surfaces are smooth, while in the technical size one surface is smooth and one frosted. Both forms of quartz apparatus are not attacked by any acid except hydrofluoric. They are also very refractory and melt above 2900° F. Quartz has a very small coefficient of expansion, only about $\frac{1}{17}$ that of glass, hence it will not crack on subjection to the most violent and sudden changes of temperature. It may be heated red-hot and put in cold water without cracking. It has high electrical insulating properties and may be used to good advantage to replace platinum, fine porcelain and glass for many purposes in the chemical laboratory and in manufacturing. The price of the electroquartz compares very favorably with that of porcelain, and indeed when we take into consideration the inconstructibility of the former, it is much the cheaper of the two. Laboratory crucibles in electroquartz may be obtained shaped similar to Berlin porcelain crucibles and at a price very slightly

higher than the latter. Quartz combustion tubes, basins, and triangles may also be obtained at prices but little higher than those for similar porcelain ware. Transparent quartz costs about ten times as much as electroquartz, and where translucent apparatus can be employed, the latter would seem to be excellent for every purpose.

The electrical alarm Pyrometers are intended to indicate when the temperature of the furnace exceeds a given point. In using them a long rod is placed in the furnace and the contact figures in the gauge are set as desired. When the heat rises or falls below the limit, an electric current is sent through the bell and rings the alarm. These pyrometers are inexpensive and very efficient. All those interested in high temperature control should correspond with Wilson-Macaulen relative to these pyrometers.

WESTMINSTER SERIES OF TECHNICAL BOOKS.

The D. Van Nostrand Company announce the publication of the Westminster series of books, dealing with the this series will be issued at short intervals, uniformly bound in cloth and containing from 200 to 400 octavo pages. They will all be illustrated and sell at the uniform price of \$2.00. The titles of the series already issued are as follows:

India Rubber, by H. L. Terry, F. I. C.
Electric Power and Traction, by F. H. Davies, A. M. I. E. E.

Liquid and Gaseous Fuels, by Prof. Vivian B. Lewes, F. I. C., F. C. S.

Coal, by James Tonge, M. I. M. E., F. G. S., etc.

Iron and Steel, by J. H. Stansbie, B. Sc.

Town Gas, by W. H. Y. Webber, C. E.

The Book, by Cyril Davenport, V. D., F. S. A.

Glass Manufacture, by Walter Rosenhain, B. A., B. C. E.

Patents, Designs and Trade Marks, by Kenneth R. Swan, B. A.

Precious Stones, by W. Goodchild, M. B., Ch. B.

Those in preparation are as follows:

Electro Metallurgy, by J. B. C. Kershaw, F. I. C.

National Sources of Power, by Robert S. Ball, B. Sc., A. M. Inst. C. E.

Radio-Telegraphy, by C. C. F. Monekton, M. I. E. E.

The Manufacture of Paper, by R. W. Sindall, F. C. S.

Wood Pulp and Its Applications, by C. F. Cross, E. J. Bevan and R. W. Sindall.

Steam Engines, by J. T. Rossiter, M. I. E. E., A. M. I. M. E.

Gold and Precious Metals, by Thomas K. Rose, D. Sc., of the Royal Mint.

Electric Lamps, by Maurice Solomon, A. C. G. I., A. M. I. E. E.

Timber, by J. R. Batterden, A. M. I. C. E.

The Railway Locomotive, by Vaughan Pendred, M. I. Mech. E.

Leather, by H. Garner Bennett.

Pumps and Pumping Machinery, by J. W. Rossiter, A. M. I. M. E.

Workshop Practice, by Prof. G. F. Charnock, A. M. I. C. E., M. I. M. E.

HYDROFLUORIC ACID FOR CLEANING CASTINGS.

The General Chemical Co. are now manufacturing at the Moro Philips Works, Philadelphia, Pa., hydrofluoric acid in large quantities. This acid will be found superior to sulphuric or muriatic acids for cleaning castings, as it eats away the sand without attacking unduly the metal. The acid can also be applied to advantage to the cleaning of brass castings which are to be plated, as the acid leaves a purer metallic surface than do the other acids, and does not cause a rusting out of the work through the final coat. The General Chemical Co. is furnishing this acid in special lead barrels holding about 400 pounds or in lead carboys of 100 pounds each.

STANDARD TESTING SIEVES.

The W. S. Tyler Co. of Cleveland, Ohio, announce that they have placed on the market a set of standard testing sieves. They are made in sizes from 6 to 12 inches in diameter, and from 2 to 200 meshes. The sieves are made with dies that produce a seamless metal rim. Across the strong frame thus formed, the cloth is stretched tightly making the construction durable. The 6, 7 and 8-in. sizes are furnished with cover and bottom which are pressed from a sheet of metal to fit each sieve in the set. The sieves may be obtained in nests, that is the extended rim of each sieve fits on top of another sieve of the same diameter. Telescope nests may also be obtained in which one sieve fits within the next one, etc. The wire cloth used in the sieve is claimed to be of standard mesh, even for very small sizes and is the well known "Tyler" double crimped wire cloth. The meshes are square and made from the same gauge wire both ways. We recommend those of our readers who are interested in the subject of test sieves to correspond with the Tyler Co. relative to supplying their needs.

DREVERHOFF'S FILTER PAPERS.

Max Dreverhoff Co., Dresden, Germany, well known manufacturer of filter papers for use in the chemical laboratory, announce that they have appointed the old and well known firm of The Henry Heil Chemical Co., St. Louis, Mo., their sole representatives for the United States and Mexico. They further announce that the latter firm will at all times keep on hand an ample stock of their various grades of filter paper. These latter have been used extensively by chemists throughout the world, and have given good satisfaction wherever tried.

FILTER PRESSES FOR METALLURGICAL WORK.

We have received from Wm. R. Perrin & Co., Chicago, Ill., a pamphlet describing their various forms of filter presses for metallurgical work. Three forms are illustrated and listed in the circular. The first of these is the Hydraulic Closing Slime Press, which it is claimed contains the best features of the foreign type of press. This press is of the kind

known as the "flush plate and division frame type," in which the plates are flat without recesses, and the chamber is formed by a division frame, the width of which determines the thickness of the cake. In this press all feeds and exits are formed in projecting lugs and are made tight by means of rubber rings set into the metal surface. Thus allowing the use of cloths that do not have to be perforated to match the feed and which saves time in setting up and admits a much tighter press. The second form of press illustrated is one intended especially for the separation of precipitates of the chlorination process and for the separation of zinc precipitates in the cyanide process. This press has been adopted as a standard for this kind of work in the large chlorination works of Colorado City. With this form of press filter paper is used in conjunction with filter cloths and the paper is stripped off and burned to recover the values. The third form of filter press illustrated has round recess plates and is intended for the cleaning up of slimes from the precipitation bags in the cyanide process and for the quick separation of solids held in suspension and to the drying of the same into solid cakes. This latter press is very simple in its construction.

RECENT INVENTIONS.

The following recent inventions have been specially reported by C. L. Parker, solicitor of chemical and metallurgical patents, 908 G Street, N. W., Washington, D. C.

923,152. *Silicon Alloy*. John T. H. Dempster, Schenectady, N. Y. June 1, 1909.

The alloy contains silicon and tellurium.

923,232. *Process for Making Alcohol*. Adolph Woolner, Jr., and Aladar Lassloffy, Peoria, Ill. June 1, 1909.

The process consists in growing diastase secreting fungi in a fluid medium adapted for its reception and development, combining the thus prepared medium with a mash containing malt-diastase and distilling the mass after the same has been brought into fermentation.

923,358. *Non-Conducting Compound*. Franc J. Jewett, New York, N. Y. June 1, 1909.

The composition comprises short asbestos fiber, grannulated cork, disintegrated sponge, and infusorial earth, the cork being treated with boracic acid.

923,411. *Manufacture of Zinc-Dust*. Sherard O. Cowper-Coles, London, England. June 1, 1909.

The process consists in electrodepositing zinc in a spongy form and subsequently drying such spongy zinc in a reducing atmosphere.

923,427. *Process of Treating Petroleum Sludge to Produce Pitch, Asphalt, etc.* John L. Gray, Elizabeth, N. J. June 1, 1909.

The process consists in removing the major portion of the acid and then heating.

923,428. *Process of Treating Petroleum Sludge*. John L. Gray, Elizabeth, N. J. June 1, 1909.

The process consists in digesting the sludge until a light grade of unsaturated hydrocarbons rise to the top, withdrawing such light grade and the acid, then digesting again until the next lighter grade rises, removing that grade and acid, and so continuing until there remains a solid residuum.

923,429. *Process of Separating Acid From Petroleum Sludge*.

John L. Gray, Elizabeth, N. J. June 1, 1909.

The process consists in washing or digesting a sludge from which the major portion of the acid has been separated, and employing the accumulated acid of a succeeding washing or digesting to separate the acid from another body of sludge.

923,581. *Process for the Production of Carbon-Covered Metal Sheets for Dynamo Brushes*. Johannes F. P. Ringsdorf, Essen-on-the Ruhr, Germany. June 1, 1909.

The process consists in smearing a carbon paste on the surfaces of said metal sheets and subjecting them to high pressure.

923,589. *Manufacture of Films For Photographic Purposes*. John H. Smith, Zurich, Switzerland. June 1, 1909.

The process consists of squeezing together into intimate contact two layers of gelatin which have been previously coated with a protecting layer of nitrocellulose solution and coating one of the layers of nitrocellulose solution with a sensitive photographic emulsion.

923,605. *Method of Consolidating Flue-Dust For Use in the Manufacture of Steel*. William Thomlinson, Seaton Carew, West Hartlepool, England. June 1, 1909.

The process consists in suitably molding flue-dust into masses provided with channels, and then utilizing the channels to aid in breaking up the masses into lumps of a size suitable for charging into said furnace.

923,761. *Process of Producing Nitro-Compounds*. Oskar Boeters and Richard Wolfenstein, Berlin, Germany. June 1, 1909.

The process consists in heating aromatic compounds which are to be nitrated with a mixture of nitric acid and a mercury salt, and in distilling off the volatile products from the nitro phenols which are produced.

923,846. *Process of Extracting Nitrogen From Air*. Oliver P. Hurford, Chicago, Ill. June 8, 1909.

The process consists in first burning a carbonaceous fuel in the presence of air of sufficient quantity for complete combustion to carbon dioxide and practically free from carbon monoxide, then subjecting the gaseous products to the condensing action of water and also passing them in contact with calcium hydroxide in water to condense the steam and separate the carbon dioxide from the nitrogen and neutralize the acid in the solution and then leading off the nitrogen from the condensing chamber.

923,864. *Process for The Electric Dissociation of Metals by the Wet Method*. Alfred Levy, Paris, France. June 8, 1909.

The process consists in placing the article to be coated in a bath consisting of a 10% to 20% alkaline solution containing a metallic salt, placing in the solution a quantity of the metal with which the article is to be coated, and connecting both the article and the coating metal to a suitable source of electricity; the former as the cathode and the latter as the anode.

923,891. *Manufacture of Bituminous Road-ways*. Clifford Richardson, New York, N. Y. June 8, 1909.

The process consists in preparing bituminous paving material by the combination of a graded mineral aggregate with a bituminous cementing material by first mixing all of the required cementing material while hot with the coarser portion of the cold aggregate and subsequently adding the finer part of the aggregate.

923,916. *Method of Thionous Precipitation*. George C. Westby, Murray, Utah. June 8, 1909.

The method consists in treating iron with a solution of sulphur dioxide, whereby a liquor containing thio salts of

iron is formed, and in adding such liquor to a solution containing copper and silver whereby these metals are precipitated therefrom.

923,925. *Composition of Matter*. Daniel G. Ziegler, Atlanta, Georgia. June 8, 1909.

The composition consists of a body portion of sand and cement, a fibrous medium for binding the body portion together, and a water-proofing medium composed of gum arabic, alum and beeswax.

923,967. *Process of Producing Camphene*. Charles Glaser, Baltimore, Md. June 8, 1909.

The process consists in subjecting bornyl-chloride to distillation under conditions which will permit the escape of hydrochloric acid and the collection of the camphene as a distillate.

924,076. *Process for Obtaining Pure Copper*. Lucien Jumau, Paris, France. June 8, 1909.

The process consists in subjecting a solution containing salts of copper to the action of carbon monoxid, and simultaneously subjecting the solution to heat and pressure.

924,077. *Process for Obtaining Pure Metallic Copper from a Solution of a Salt of Copper*. Lucien Jumau, Paris, France. June 8, 1909.

The process consists in subjecting a solution containing a salt of copper to heat and pressure, in the presence of gaseous reducing agent containing hydrogen.

924,086. *Road-Surface Preparation*. William A. Meadows and Sydney C. Meadows, Liverpool, Eng. June 8, 1909.

The composition of a mixture of that portion of coal-tar remaining after the removal therefrom of the middle and heavy oils, and coal tar naphtha.

924,101. *Preparation or Regeneration of Rubber or Caoutchouc*. Francis W. Passmore, London, Eng. June 8, 1909.

The process consists in preparing caoutchouc from rubber waste or other material containing the same by dissolution of said material in eucalyptol, addition of a volatile diluent, separation of undissolved matter from the dilute solution, removal of the diluent and separation of the caoutchouc from the eucalyptol.

924,117. *Preparation of Caoutchouc*. Auguste Tixier, Paris, France. June 8, 1909.

The process comprises extraction of material containing caoutchouc with an oxygen derivative of a terpinic hydrocarbon said derivative having a melting point below 150 degrees C.

924,130. *Method of Reducing Ores*. Frederick M. Becket, Niagara Falls, N. Y. June 8, 1909.

The method consists in smelting a charge containing such ore and boron, while applying heat to the charge and maintaining therein a temperature sufficient to reduce the same.

924,319. *Extraction of Gum*. Peter C. D. Castle, Bebington, England. June 8, 1909.

The process consists in obtaining gum tragacanth from the split locust kernels with the still adhering husks by soaking the same in cold water and a substance capable of rendering the coloring matter insoluble, gradually adding further water with head and stirring, and pressing out the gum solution.

924,494. *Process of Preparing Pure Lactic Acid*. Hugo Noerdlinger, Arnaldo, Caroselli, and Ludwig Berg, Florsheim-on-the-Main, Germany. June 8, 1909.

The process consists in preparing pure lactic acid from crude concentrated lactic acids, by distilling off the pure lactic acids by a current of gas, not liquefiable at ordinary temperature and inert against lactic acid, and in separately collecting the distilled pure lactic acid.

924,584. *Process of Obtaining Pure Caoutchouc, Gutta-Percha, and the Like*. Heinrich Scholz, Berlin, Germany. June 8, 1909.

The process consists in dissolving the resin with anilin, or its alkylized substitution products, while maintaining the temperature below the melting point of rubber, and then separating the pure caoutchouc and gutta from the solution.

924,677. *Process of Smelting Iron Oxides*. Horace W. Lash, Cleveland, Ohio. June 15, 1909.

The process consists in charging into a furnace a smelting mixture containing finely divided oxide of iron, finely divided cast iron and carbonaceous material, and also disposing in said furnace a quantity of pig metal in proper manner to form a bath beneath the smelting mixture and applying a smelting heat to the charge.

924,770. *Art of Treating Wood for Lumber*. William A. Hall, New York, N. Y. June 15, 1909.

The process consists in dissolving bark phlobaphenes with an alkali and then impregnating the wood with the phlobaphene solution.

924,792. *Detergent*. Adolf Kayser, Buffalo, N. Y. June 15, 1909.

The composition consists of a soap having intermixed therewith, one molecular weight of alumina two to eight molecular weights of silica, and four to six molecular weights of alkali metal oxid.

924,818. *Process of Producing High-Grade Steel From Low-Grade Material*. William R. Palmer, Bridgeport, Conn. June 15, 1909.

The process consists in charging a primary furnace with low grade material, operating the furnace at a temperature below ordinary steel-making temperatures, partially charging a secondary furnace with low grade material, operating said furnace at ordinary steel-making temperatures, transferring a portion of the charge from the primary furnace to the secondary furnace for the completion of the refining operation and returning a portion of the charge to the primary furnace to form a bath to receive the next charge of low grade material.

925,104. *Method of Manufacturing Artificial Cork*. Bronislau Honowsky, St. Petersburg, Russia. June 15, 1909.

In this method cork chips or waste are mixed with sodium xanthate, heavy metallic oxides with an addition of acids, and indifferent substances, glycerine and mineral oil, and this mixture is pressed in molds and dried, for the purpose set forth.

925,253. *Process of Making Ammonia and Chlorine or Hydrochloric Acid*. Norman L. G. Whithouse, Lewisham, London, Eng.

The method consists in making ammonia and chlorine from ammonium chloride by heating at a low temperature ammonium chloride with cerium oxide whereby ammonia is expelled and then heating the residue at a higher temperature in an oxidizing atmosphere.

925,365. *Metallization of Vitreous Ceramic Surfaces*. Quentin Marion, London, England. June 15, 1909.

The metallizing of ceramic surfaces is effected by applying thereto a solution resulting from dissolving in hydrofluoric acid a gray substance consisting of filiform silver and basic nitrate of copper, and then, while the surface is wet with the solution, dusting said surface with a metal in a finely divided state and such as will reduce the silver and copper in the fluoride to a metallic state.

925,429. *Finish-Remover and Process of Making the same*. Carleton Ellis, Larchmont, N. Y. June 15, 1909.

The process of preparing the finish remover consists in dissolving potassium acetate in alcoholic finish solvent material, and incorporating therewith penetrating solvent material in which waxy stiffening material has been dissolved

and in agitating the mixture and adding acid to substantially neutralize the developed alkalinity.

925,612. *Refining of Steel in Electric Furnaces.* Otto Thallner, Bismarckhütte, Germany. June 22, 1909.

The process consists in refining the steel to a high extent in a basic lined electric furnace and then treating the same in an acid lined electric furnace.

925,658. *Preparation of Chloroform in a Solid Condition.* Carl L. Schleich, Berlin, Germany. June 22, 1909.

The preparation is a solid chloroform-containing compound comprising a solid peptone having chloroform incorporated with it.

925,659. *Alloy for Armor-Plates and Other Uses.* Eugene Schneider, LeCreusot, France. June 22, 1909.

The alloy contains in one hundred parts, in addition to iron, carbon, 0.3 to 0.5, manganese less than 1.5 and tungsten less than 3.

925,670. *Composition for Oxidizing and Purifying Explosion Gases.* Herbert Walker, Knights, Transvaal. June 22, 1909.

The composition consists of permanganate of potassium, chloride of ammonium, and chlorate of potassium, in the following proportions: Permanganate of potassium, ten pounds; ammonium chloride, one-half dram; potassium chlorate, $1\frac{1}{2}$ to 3 drams.

925,894. *Method of Treating Fabrics to Render them Adhesive.* Frederick J. Gleason, Walpole, Mass. June 22, 1909.

The process consists in applying to a face thereof a composition containing gutta percha and a body capable of maintaining the same in a plastic state, permitting the coating to dry, and subjecting said coating to the action of a solvent for the plastic components.

925,988. *Process of Hardening Tantalum.* Werner von Bolton, Charlottenburg, Germany. June 22, 1909.

The process consists in adding to tantalum less than 10 per cent and more than 1 per cent of silicium.

926,084. *Process of Purifying Tungstic Anhydride.* Edward P. Beckwith, Schenectady, N. Y. June 22, 1909.

The process consists in heating tungsten trioxide in vapor of carbon tetrachloride to produce a volatile product and to separate impurities non-volatile at red heat.

926,280. *Process of Preparing Concentrated Hydrated Magnesia.* Winfield S. Morrison, Oakland, Calif. June 29, 1909.

The process consists in preparing a concentrated magma of magnesium hydroxide by agitating and boiling the magma with a separate portion of water and settling each day for several days.

926,289. *Process for Desulphurizing and Agglomerating Ores.* Cyrus Robinson, Mount Vernon, N. Y. June 29, 1909.

The method consists in continuously desulphurizing ores, by maintaining a zone of heat in a passing stream of ores without the use of extraneous fuel.

926,352. *Method of Purifying Coal-Gas and Collecting By-Products.* Thomas McWatters, Hawkins Station, Pa. June 29, 1909.

The process consists in purifying coal gas and collecting the by-products thereof, passing the gas at a temperature of 300 Fahrenheit or thereabout through a washer and thereby reducing the temperature of the gas to a temperature sufficient to eliminate substantially all the tar from the gas, the lowering to and maintaining the gas at a temperature sufficient to prevent the ammonia present assuming gaseous form, and finally by a further reduction in temperature eliminate the lighter tar and the liquor containing the remaining ammonia.

926,413. *Process for Oxidizing Atmospheric Nitrogen by Electricity.* Demetric Helbig, Rome, Italy. June 29, 1909.

In this process compressed air is projected by means of

two opposite nozzles arranged in line against an arc produced by a three-phase current between three suitable electrodes arranged at an angle of 120° relatively to each other, whereby a flame disk is produced which spreads out in a plane at a right angle to the axis of the nozzle.

926,718. *Process of Extracting Metals from Their Ores.* William T. Smith, Los Angeles, California. June 29, 1909.

The process consists in leaching ores by introducing superheated steam into a circulatory channel in open communication with a tank containing a cyanide solution, said steam serving as the sole heating and circulation compelling agent.

921,312. *Treatment of Pyrites Liquor for Winning Metals Therefrom.* John H. Thwaites, Peterborough, England. May 11, 1909.

This treatment of liquors obtained from pyrites cinder or the like and from which copper has been removed consists in adding to the liquor a zinc compound adapted to precipitate iron as hydrated ferric oxide, then peroxidizing the mixture, thus removing the precipitate thus formed and finally adding a sulphide adapted to remove materials which would prevent the precipitation of white zinc sulphide from the liquor.

921,329. *Process of Making Sodium Sulphate and Sulphuric Acid.* Oskar Zahn, Berlin, Germany. May 11, 1909.

The process consists in decomposing sodium bisulphate, with the aid of water, into sodium sulphate and hydrated sulphuric acid, and in heating the same to drive off this acid, and to calcine the sulphate.

921,372. *Process of Separation of Metals.* Richard Divine, Chicago, Ill. May 11, 1909.

922,409. *Process of Recovering Hydrocyanic Acid.* Walther Feld, Honningen-on-the-Rhine, Germany. May 18, 1909.

The process consists in obtaining hydrocyanic acid from metallic cyanides in a solid state by subjecting the latter at a temperature above 100° C., and in the presence of steam to the action of acid and maintaining the reacting mass at least in part above the reaction liquid.

922,494. *Process of Making Fertilizing Material.* John W. Lowman, Nashville, Tenn. May 18, 1909.

The process consists in pulverizing a predetermined amount of phosphate material, burning and pulverizing a predetermined amount of dolomite or magnesium lime stone, burning and pulverizing a predetermined amount of fluorspar, thoroughly mixing all of said material, and reducing the same to a plastic mass by mixing water therewith and then heating the plastic mass thus produced.

922,523. *Flux for the Autogenous Welding of Aluminum.* Max U. Schoop, Bois Colombes, France. May 18, 1909.

The flux consists of chloride of potassium, chloride of sodium, bisulphate of potassium, and chloride of lithium.

922,995. *Salicylic-acid Derivative and Process of Making the Same.* May 18, 1909.

The process consists in submitting a starting compound containing the salicylic acid radical to the action of a condensing agent in a quantity not exceeding the amount necessary to split off one molecule of water from two molecules of the salicylic acid radical.

923,005. *Process of Treating Nickel Ores.* Anson G. Betts, Troy, N. Y. May 18, 1909.

The process consists in smelting the ore to an alloy of iron and nickel containing a considerable proportion of iron, and electrolytically refining the alloy, with a solution containing a nickel and an iron salt as electrolyte, producing refined nickel-iron cathode metal containing more than 20% of iron.

923,012. *Production of Cyanide and Cyanamide.* Carl Bosch and Alwin Mittasch, Ludwigshafen-on-the-Rhine, Germany. May 18, 1909.

The production of cyanides and cyanamides of the alkali metals and of the alkaline earth metals is accomplished by heating a titanium nitride with carbon in the presence of a metallic compound.

923,116. Method of *Recovering Values from Alluvial Deposits*. Ole T. Crosby, Nome, Alaska. May 18, 1909.

The method consists in cutting the ground to be treated into spiral layers, injecting fluid into each layer as cut to separate the particles, collecting the gravitating valuable particles, and removing the so collected particles from under the cut layers without removal of the latter.

The process consists in separating the oxides of lead, antimony and zinc, by mixing said oxides with oil cake and sodium carbonate, and heating said mixture sufficiently to reduce the oxides to the metallic state and vaporize the zinc.

921,382. *Furniture-Polish and Process for Producing Same*. Gustav Elkeles and Ernst Klie, Berlin, Germany. May 11, 1909.

The polish is composed of an intimate mixture of resin and a small percentage of unsaponified wax and an alcoholic solvent for said mixture, said polish being characterized by an exceedingly fine and even division of the wax throughout the solution.

921,502. Chemical Process for the *Treatment of the Straw of Flax or other Plants*. Anne-Marie de Montessus de Ballore, Tunis, Tunis. May 11, 1909.

The treatment consists in eliminating the straw from the binding gums which unite the pecto and ligno cellulose structures, oxidizing the ligno cellulose without injuriously affecting the pecto cellulose and recovering the ligno and pecto cellulose by decantation separately by passing the same through a strainer adapted to retain the pecto cellulose fibers alone, and subsequently recovering the ligno cellulose from the suspension water.

921,641 Method of *Preventing Corrosion of Metals Immersed in Liquids*. Peregrine E. G. Cumberland, St. Kilda, Victoria, Australia. May 11, 1909.

The method is for preventing the corrosion and decomposition of propeller shafts and other metallic portions of ships immersed in or in contact with sea water and whereby two or more electrically opposed metals are in juxtaposition and connected in parallel and constitute a negative electrode and consists in placing additional iron means in contact with the water in proximity to the metal parts to be protected and insulating said iron means from said parts except through the sea water, and connecting said metal means in parallel and to the positive pole of an auxiliary source of electrical energy having a higher E. M. F. than that caused by the difference of electric potential between the various metals comprised in the structure to be protected, and connecting the negative pole of said source of energy and said metals to be protected constituting the negative electrode.

921,686. Production of *Titanium Oxides*. Francis A. J. Fitz Gerald and Peter M. Bennie, Niagara Falls, N. Y. May 18, 1909.

The process consists in subjecting crushed ilmenite to the reducing action of powdered carbon, producing a sintered mass therefrom, subsequently crushing the sintered mass, and removing the reduced iron from said mass.

921,838. Composition of Matter for the Use in *Fire-brick* and the like and process of producing the same. Luke Houze, Monterey, California. May 18, 1909.

The composition consists of about twenty-one parts of fire clay binder with about seventy-nine parts of a filler consisting of hydrophane which is roasted and crushed to a state of coarse division.

921,879. *Brick-glazing Compound*. Henry Ohlsen and John Ohlsen, Loup City, Nebraska. May 18, 1909.

The composition comprises one part lead pigment, one part muddy clay water, one part blue vitriol water, one part air-slaked lime and one part alcoholic liquor.

921,925. *Method of Treating Armor or Deck Plates*. Samuel S. Wales, Munhall, Pa. May 18, 1909.

The method consists in preparing a steel plate containing vanadium, imparting a fibrous character to the plate by heat treatment, then hardening the plate by raising it to a higher temperature than that employed in fibering, and then annealing the plate.

921,943. Process for *Electrically Closing With Tin or Allied Metals*. Jay C. Beneker, Waukegan, Ill.

The plating solution of tin comprises approximately 25 parts sodium hydrate, 15 sodium thiosulphate and 10 parts stannous chloride and 200 parts of water.

921,975. Process of Obtaining *Nitric Acid* from Gas Mixtures Containing Oxides of Nitrogen. Ludwig Glaser, Berlin, Germany. May 18, 1909.

The process includes the steps of absorbing the nitric oxide by means of a weak basic oxide, and subsequently heating to a high temperature to drive out the nitric oxide in concentrated form.

922,003. Process of Making *Ammonia*. Constantin Krauss, Westeregeln, Germany. May 18, 1909.

The process consists in producing ammonia from suitable cyanogen compounds by subjecting a mixture of the same with chloride of calcium to the action of water and heat.

922,031. Method of Making *Sodium Sulphate*. John D. Pennock, Syracuse, N. Y. May 18, 1909.

The method consists in mixing niter cake and sodium compound, having an alkaline reaction, in approximately reacting proportions, then effecting a reaction between the acid and alkaline components and recovering the resulting sodium sulphate.

922,088. Process of *Removing Sulphur, Arsenic, and other like Impurities from Refractory Ores*. Frank Cotton, Hornsby, New South Wales, Australia. May 18, 1909.

This is a process for the preparation of auriferous and argentiferous refractory ores contaminated with impurities such as sulphur, arsenic, antimony, zinc and the like, consisting in the removal of the sulphur by the action upon the heated ore of free hydrogen under slight pressure, the subsequent oxidation of the base metals capable of oxidation present in the desulphurized ore by the action of steam upon the same and the final driving off by heat from the desulphurized and oxidized ore of the remaining volatile oxide present.

922,339. Process for the Agglomeration and *Regeneration of India-Rubber, Gutta-Percha, and Their Artificial Substitutes*. Emile A. L. Rouxville, Paris, France, May 18, 1909.

The process consists in regenerating waste india-rubber, gutta percha and their artificial substitutes by mixing the same with the polymerized products of oil of turpentine and then to an alkali and sulphuric acid.

922,340. Manufacture of *Objects from Cellulose Acetate*. Albert Schloss, Stettin, Germany. May 18, 1909.

The process comprises the subjection of the cellulose acetate to the action of formic acid as a solvent and the introduction of the solution so formed into an aqueous precipitating bath.

922,309. Process of *Extracting Resin and Turpentine*. George Walker, New York, N. Y. May 18, 1909.

The process comprises distilling off volatile bodies from a resinous wood at a temperature insufficient to injure the resin, and subsequently extracting the wood with a neutral volatile solvent to remove resin.

922,388. Process of Making *Ferro-Nickel and Nickel-Steel*. Franklin R. Carpenter, Denver, Colo. May 18, 1909.

The method consists in freeing sulphide copper-nickel-iron ores from their copper contents by oxidizing the nickel and iron sulphides and then chloridizing the copper sulphide and leaching the same from the mass, leaving the nickel and iron oxides in the form of the purple ore of commerce, and the smelting of this purple ore for the production of ferro-nickel or nickel-steel.

The Chemical Engineer

PUBLISHED BY

The Chemical Engineer Publishing Co., 355 Dearborn St., Chicago

Vol. X.

SEPTEMBER, 1909.

No. 3.

CREOSOTE OIL FROM WATER GAS TAR.*

By SAMUEL P. SADTLER, L.L. D.

Consulting Chemist, Philadelphia, Pa.

It is stated in a bulletin of the Forest Service of the United States Department of Agriculture about to be issued that more than 56,000,000 gallons of creosote oil were used last year in preserving timber in the United States. Of this amount 69 per cent was imported and 31 per cent was obtained from domestic sources. These figures are based upon reports to the service of forty-four firms which operated sixty-four timber treating plants.

The only other timber treating agent in practical use was zinc chloride of which 10,000,000 pounds were said to have been used.

Both are excellent antiseptics and are commercially available. The principal point of superiority of creosote lies in its insolubility in water. Zinc chloride being soluble will leach out from timbers injected with this salt if the timbers are exposed to moisture. Moreover, creosote is the only material which will effectually protect timbers submerged in ocean waters from the teredo or common ship worm, which works such havoc among the wharves of the Atlantic, Gulf and Pacific Coasts. If properly injected, it cannot wash out and is hence superior to any mere external coating. Let us therefore dismiss all consideration of any other material than creosote oil and turn to the consideration of this substance.

What is it? Allen (Com. Org. Anal., 3 Ed., Vol. II, Part II, p. 294) says, "*Coal Tar Creosote Oil*, commonly consists of that portion of coal tar which distills between 200° and 300° C., together with the residual oils from the manufacture of crude carbolic acid, naphthalene and anthracene. This description, however, applies especially to the creosote oil produced in the best managed works. In some works, every residue which cannot be used for any other purpose finds its way into the Creosote-oil well." In consequence of this uncertainty of composition, most railroads and other large users of creosoted timber have had prepared more or less rigid specifications as to what should be the physical and chemical characters of

a creosote oil to be used for the impregnation of timbers.

These specifications had reference to specific gravity, percentage of phenols (or tar acids), of naphthalene allowable, and to the range of temperature within which the oil should distill. Until recently most experts valued the tar acids and naphthalene as the important constituents and demanded definite percentages of each. Now the weight of opinion is in favor of the heavy oils which come over after the naphthalene in the distillation and considers the naphthalene as of no value whatever. This is because naphthalene is volatile at all temperatures and will disappear entirely from the wood in course of time.

As illustrating the views held on the subject of the proper composition for a creosote oil for timber preservation I will quote a few foreign specifications and a few American ones of different dates:

The Belgian State Railways specify for creosote oil, "Specific gravity 1.05 at 15° C., 5% tar acids, one-third distilling at 200°-250° C. and two-thirds at 250° and above."

The Western Railway of France.—"Specific gravity minimum 1.015 at 50° C., 6% acid, should be completely liquid at 40°, at 15° a minimum of 10% and a maximum of 25% solid deposit allowed."

Roumanian State Railway.—"Specific gravity 1.05 to 1.10 at 15°, 6% to 10% phenol, one-third distilling at 200°-250°, 1% green oil between 288°-400°, completely liquid at 40°, 10% to 30% of naphthalene."

German Impregnating Works.—"Specific gravity 1.02 to 1.055 to 15%, 10% to be dissolved in soda solution of 1.15 Sp. gr., up to 150° nothing distilling, 150°-235° 25% as a maximum, all should distill between 150°-400° C."

Letheby's English Specifications.—"5% acids, 90% should distill below 315° C.

Midland Railway Co. of England.—"Specific gravity of 1.04 to 1.065 at 90° F., not less than 25% not distilling at 600° F. (315° C.) and not less than 6% tar acids."

Of these specifications, the Belgian, German and Midland Railway Co. show the influence of the more recent views while the others practically demand naphthalene and do not insist on the heavier oils as essential. The American specifications are all of

*Paper read at the Brooklyn meeting of The American Institute of Chemical Engineers and presented in complete form for publication in the Transactions of the Institute.

relatively recent date and show in the main the change of views as to what is considered as desirable.

Herman von Shrenk of the United States Forestry Bureau in 1903 (Year-book of the Department of Agriculture for 1903, p. 435) proposed the following: "The specific gravity must be about 1.04 to 1.10 at a temperature of 20° C. The boiling point must be as follows: up to 150° C. nothing must come off; up to 200° C. not more than 10% may come off; up to 235° C. not more than 25% may come off; up to 355° C. at least 90% must come off. The oil must be soluble in benzene or in absolute alcohol."

These specifications are relatively high. In 1905, E. H. Bowser, of Louisiana, who had been practically engaged in creosoting work in that state (See Hour. Association of Eng. Societies April, 1905.), proposed: "The specific gravity shall be not less than 1.04 at 35° C.; it shall not yield more than 10% by weight when distilled up to 210° C.; between 210° and 235° C. the distillation shall not be less than 25 nor more than 30% and at least 30% by weight shall not distill below 260° C." These specifications were quoted with approval by H. R. Stanford in a paper read before the American Society of Civil Engineers, Dec. 20th, 1905.

In Circular 141 of the Forest Service, United States Department of Agriculture, entitled, "Wood paving in the United States," the specifications of the city of Minneapolis for creosote oil for wooden block impregnation are given. These state: "The specific gravity of the oil at 20° C. shall be at least 1.09; the oil shall be completely liquid at 25° C. and show no deposit on cooling to 22° C.; it shall not contain more than 2 per cent of water, nor more than 3 per cent of matter insoluble in absolute alcohol or benzene on distillation, up to 150° C., nothing must come off, up to 170° C. 2%, up to 210° C. from 6% to 8%, up to 325° C. from 20% to 30%, up to 315° C. from 40% to 50%, up to 355° C. from 60% to 80%." It will be seen that this calls for a relatively heavy oil, containing high boiling fractions.

The most recent publication which deals with this subject in detail is Circular 112 of the Forest Service on "The Analysis and Grading of Creosotes," by Dean & Bateman, issued Feb. 26th, 1908. The authors have studied a large number of samples of creosote oil from coal tar as well as from other sources, and as a result of their studies propose 4 grades of creosote oil, designated respectively as Grades A, B, C and D. They give the distillation curves of each of these as well as note their accordance with certain limits of specific gravity, index of refraction and percentage of oil remaining after sulphonation test. The distillation range as might be expected, is high for the better grade oils.

The question as to what should be the composition of a creosote oil has been attacked, however, with very satisfactory results, by extracting the oil from creosoted timber which has stood exposure for some years and examining it as to its composition. Thus,

von Schrenk in 1907 in a paper read before the New England Railroad Club gives as the result of his examination of oil extracted from creosoted timber in service from 1897 to 1906 percentage figures indicating that "during the nine years of exposure, the naphthalene fraction has practically disappeared from the wood above the ground." In that part of the creosoted timber below the ground it had diminished but had not disappeared.

Prof. Gellert Alleman, however, has more recently published a fuller study of this question of the character of the extracted oils. He obtained these oils from railroad ties, piles, and paving blocks, in all 37 samples, which had been creosoted in both English and American practice and had been in service for periods varying from 9 to 47 years. His conclusions are as follows:

"The creosotes recovered contained practically nothing which boiled below 205° C. The general average shows that 32.9 per cent of the oils distilled below 270° C. and 66.95 per cent above—that is, two-thirds above and one-third below this rather high temperature. Another noticeable fact is the large amount of solid anthracene oil recovered from the distillates of many samples, the highest being 57 per cent.

A distinctive feature of the creosotes from American piles was the quantity of naphthalene which they contained. The average from this class of timbers was nearly 26 per cent and one sample showed over 48 per cent. It appears probable that the creosotes used in treating these timbers contained much more naphthalene than the oils applied to the English piles. The results indicate that this substance possesses value for timber treatment, although it probably is inferior to anthracene oil.

It is worth noting that these long-lived American piles contained more anthracene oil than naphthalene.

Perhaps the most striking thing is the disappearance of the tar acids. It is certainly conservative to place the original tar-acid content at 5 per cent. Yet the extracted oils showed but a tenth of this amount.

It appears, therefore, that light oils, boiling below 205° C., will not remain in timber, but that heavy oils, containing a high percentage of anthracene oil, will remain almost indefinitely and protect the wood from decay and boring animals. It is probable that naphthalene stays in wood for many years, but whether it is as valuable as anthracene oil is an open question. The value of the tar acids has apparently been overestimated by many persons, for although it has not been proved that they are valueless, they have been shown to possess poor staying qualities.

The Circular 112 of the Forest Service on "The Analysis and Grading of Creosotes," by Dean and Bateman, to which reference has already been made, is one of great importance in that it seeks to reduce to more exact definition the characters that should give value to creosoting oils. They say as bearing on this, "the important chemical properties of a creosote which fit it to be a preservative are those which increase its

toxic qualities towards fungi and wood-destroying insects. Although there are exceptions, it is a general rule that the compounds belonging to the aromatic series are more poisonous to both plants and animals than those in the paraffin and olefin series and the former are consequently of much greater antiseptic value. A pure coal-tar creosote will protect properly treated timber for a great many years. What protection will be afforded by the distillates from other kinds of tar is as yet an open question, but the increased production of these tars and the growing practice of distilling them make it imperative that definite information regarding their preservative value should be acquired. At present, despite the apparent approximation to the composition of coal-tar creosotes by the creosotes from oil or water-gas tars, the known preservative value of the pure coal-tar creosotes make them of greater market value. We must, therefore, regard the creosotes obtained by distillation of properly made coal-tars as the highest grades for preservation. * * * In addition to being a pure distillate from coal tar, the creosote must also possess a composition which gives it properties falling within narrow limits."

In studying selected coal-tar creosotes, they note first the difference in volatility (or percentage of volatile constituents), which, as has been seen, rapidly disappear from the treated wood and therefore have little value. They next note as the distinguishing properties of pure coal-tar creosotes the index of refraction, the specific gravity and the sulphonation test. The meaning of this last test is thus stated by the authors on p. 20 of Circular 112: "If a fraction from the distillation of a creosote oil be treated under proper conditions with concentrated sulphuric acid, it will be converted into a mixture of sulphonic acids, which will readily dissolve in water. If, however, there are paraffin bodies present, they will not be attacked to the same degree as the aromatic hydrocarbons and when the products of the sulphonation are treated with water the paraffin components will remain as residual oil. In applying this test to creosote oils, it has been found that the most information is obtained by using it on the higher boiling fractions."

Messrs. Dean and Bateman have extended their study of creosote to oils made from what they term "Oil-tar," but what I would prefer to call "water-gas tar," as designating more specifically the conditions of its formation, as the temperatures used in making carburetted water-gas are very different from those used in making what is called "oil-gas" for which so-called "gas-oils" are used. On p. 26 they summarize their results as follows: "It will be seen from these data that both the specific gravity and index of refraction is lower in the case of the oil-tar creosotes than in that of the coal-tar creosotes. Moreover, the high boiling fractions of the oil-tar creosotes always yield an oily residue from the sulphonation test. The index of refraction of this residuum is very low, falling in the general range of crude petroleum. This

indicates that some of the gas-making oils get through the producer without being decomposed and appear in the tar."

As I had put at my disposal recently a sample of creosote oil distilled from water-gas tar, made at the high temperatures now customary in the manufacture of carburetted water-gas, I have submitted it to the different tests of Dean and Bateman's pamphlet in comparison with a coal-tar creosote of known make. The physical and chemical tests upon the two oils, the distillation records and tests of different fractions from the distillation are all stated in a series of tables which are here appended.

	I. Water-Gas Tar Creosote Fraction.	II. Coal-Tar Creosote Fraction.
Specific gravity at 60° F.		
Consistency at 60° F. . . .	Relatively thin liquid.	Thin liquid
Consistency at 32° F. . . .	Still thin liquid.	Thin liquid
Index of refraction (at 40° C.)	1.637	1.563
Index of refraction (at 60° C.)	1.6315	.....
Viscosity at 100° C.	55 seconds (Engler)	47 seconds (Engler)
Sulphonation test	2.14%	1.118%
Evaporation per cent 4 hours at 98° C.	10.07%	89.3%
Percentage of phenols	None.	14%

1. Distillation Results with Water-Gas Tar Fraction.

Fraction.	Range in Temperature.	Amount in cc.	Percentage over.
1. Up to	260° C.	17.5 cc.	= 5.5%
2. 260°	310° C.	28 cc.	= 15.2%
3. 310°	330° C.	36 cc.	= 27.2%
4. 330°	350° C.	65 cc.	= 48.7%
5. 350°	370° C.	63 cc.	= 69.8%
6. 370°	380° C.	33.5 cc.	= 81.0%
7. Residue		57 cc.	= 19.0%
		300 cc.	= 100.0%

	Refractive Index.		Sp. Gr.	
	40°.	60°.	15°.	60° C.
Original	1.6370	1.6315	1.073	1.0448
Fraction 1 . . . . .	....	....	0.904	0.8758
Fraction 2	1.5892	1.5800	1.017	0.9888
Fraction 3	1.6181	1.6095	1.054	1.0258
Fraction 4	1.6371	1.6288	1.074	1.0458
Fraction 5	1.6540	1.6450	1.093	1.0648
Fraction 6	1.6525	1.6434	1.086	1.0578

1. a. Additional Distillation Results with Water-Gas Fraction.—1,500 cc. of the 1.073 water-gas tar oil were distilled in iron retort and 375 cc.; collected between 160°—343° C.; 300 cc. of this was fractioned in

a Hempel distilling flask (thermometer exposed above 65° C.; temperature of stem, 40°—85° C.).

Fractions.	Range of Temperature.	Amount in cc.	Percentage over
1	160° to 200° C.	34.5 cc.	= 11.5%
2	200° to 240° C.	24.5 cc.	= 19.7%
3	240° to 280° C.	52 cc.	= 37.0%
4	280° to 300° C.	54.5 cc.	= 55.2%
5	300° to 320° C.	37 cc.	= 67.5%
6	320° to 330° C.	27 cc.	= 76.5%
Residue		70.5 cc.	= 23.5%

	Refractive Index	Sp. Gr.
	40° C.	60° C.
Fraction 1	No film	.8537
Fraction 2	No film	.9124
Fraction 3	1.5718	.9716
Fraction 4	1.5872	1.009
Fraction 5	1.6006	1.029
Fraction 6	1.6165	1.018

Viscosity in Pipette at 180° F.

Barrett Co. Creosote Oil	25 cc. = 15 seconds
Water-Gas Tar Fraction 1	25 cc. = 15 seconds

II. Distillation Results with Coal-Tar Creosote.

Fraction.	Range of Temperature.	Amount in cc.	Percentage over
1	Up to 200° C.	27.6 cc.	= 9.2%
2	200° to 210° C.	60 cc.	= 29.2%
3	210° to 220° C.	57 cc.	= 48.2%
4	220° to 230° C.	44 cc.	= 62.9%
5	230° to 240° C.	33 cc.	= 73.9%
6	240° to 260° C.	32.5 cc.	= 84.7%
7	260° to 280° C.	17.5 cc.	= 90.5%
8	280° to 295° C.	10 cc.	= 93.5%
9	Residue in solid	18.4 cc.	= 6.5%

	Refractive Index.	Sp. Gr.
	40° C.	60° C.
Original	1.5630	1.117
Fraction 1	1.5340	0.974
Fraction 2	1.5540	0.975
Fraction 3	1.5665	0.993
Fraction 4	1.5813	1.089
Fraction 5	1.5864	1.025
Fraction 6	1.5929	1.028
Fraction 7	1.5945	1.037
Fraction 8	1.6050	1.115

I am not willing to express a final opinion on these results but hold them subject to confirmation by additional distillations. The coal-tar creosote oil which I have examined in this connection is also probably fuller of light fractions than some of the coal-tar creosote oils examined by Dean and Bateman. It will be seen however that the specific gravities of the fractions from the water-gas tar are not appreciably lower than those obtained from the coal tar creosote fractions, the indices of refraction are notably higher instead of lower, as found by Dean and Bateman, and the sulphona-

tion test shows a residue which, while larger than that of the coal-tar creosote, amounts to only 2.14%. On the other hand, the evaporation test, the freedom from phenols and the abundance of high-boiling fractions are all in favor of the water-tar creosote. The sulphonation test shows that these high-boiling fractions are not paraffins and every indication shows that they are most probably just what are indicated by Alleman, von Schrenk and others as the most desirable constituents of a creosote oil, viz., the so-called anthracene oils. Moreover the absence of phenols from this water-gas tar creosote shows that it is a product of high temperature distillation in which the paraffins have been converted into the high-boiling aromatic hydrocarbons. The identification of these higher aromatic hydrocarbons has been partially carried out and confirm this view.

I would therefore express the opinion that we may possess in this grade of water-gas tar creosote an oil quite specially adapted to wood preservation.

Wood Preserving Plant of the Pennsylvania Railroad.

The Pennsylvania Railroad Co. has just awarded a contract for the erection of a complete pressure wood-preserving plant at Point House Pier, Greenwich Point, Philadelphia. In addition to the plant to be constructed, the company has one at Mt. Union, Pa., and a small experimental plant at Greenwich Point, both of which are in successful operation.

It is estimated by the company that proper treatment will increase the life of cross-ties from two to three-fold. The Pennsylvania Railroad uses from 3,500,000 to 4,000,000 ties each year for renewals and new work. The average life of the red oak and chestnut ties under present conditions in main running tracks is from three to four years, while white oak lasts from seven to eight years. It is estimated that preservative treatment will increase the life of the red oak and other treatable ties to at least fifteen years. The new plant to be built at Philadelphia will be similar to the one now in operation at Mt. Union, except that it will be designed to accommodate an additional cylinder whenever it is needed. The building will be 50 x 150 ft., and of steel frame and corrugated iron construction. It will be absolutely fireproof. The capacity of the cylinder will be from 750,000 to 1,000,000 ties per year, working day and night shifts. The two treating plants of the company will have a capacity of 1,500,000 ties per year.

In connection with the tie-treating plant, there will be a storage yard covering an area of about 25 acres along the Delaware River. This will afford a storage capacity for from 750,000 to 1,000,000 ties. Storage tracks will be built, and a 24-in. gauge track will be laid for the operation of the cylinder cars. In addition to ties, many other classes of material will be given preservative treatment, including bridge timbers, telegraph poles, cross-arms, planking and shingles.

THE DEVELOPMENT OF THE AMMONIA INDUSTRY IN GAS WORKS DURING THE LAST FIFTY YEARS.*

By R. W. HILGENSTOCK,

Engineer, Leipzig (Plagwitz), Germany.

When one looks back and lets the past half century pass his mental eye, there will appear a picture of very characteristic looks. In the beginning of it, we see the railroads hardly started, pig iron and steel are made in a very expensive and tiresome way, rolling mills, mostly driven by water power, furnish rails and other structural iron in a very clumsy shape; the chemical industry is in its childhood yet, and not only a very few of the chemicals known in our days are made in bigger quantities; gas works, I guess, were only in the larger cities in operation. By-and-by, however, the picture changes, and we see better equipped railroads, and larger mills, and inasmuch as the gas works and chemical works have grown, the chemical preparations show an increase also. Especially, two big groups take our interest: that of ammonia and that of tar. It was only natural that, with the development of the chemistry, these two contents of the coal should evolve an industry which today gives employment and wages to many thousand employees and workmen, and the gas works can be proud to take the glory for having given birth and raised these industries.

Of course, in the beginning, means for the recovering of ammonia contained in the gas liquor were very simple, and big losses could not be avoided, until the nature of ammonia became more and better known to the chemists, who in turn gave their experience to the builders of chemical apparatus, so that today almost every concern manufacturing ammonia stills and ammonia apparatus can produce machines of excellent quality. Looking back, however, once more, we find that the gas liquor, the recovering of which I presume as known to every reader of the Journal, is boiled, in simple boilers; the escaping ammonia gases are either caught in sulphuric acid and sulphate of ammonia is recovered as end product, or they are condensed and concentrated ammonia liquor is made. Many accidents and explosions, due to blockage of the pipes with carbonate of ammonia, and crustation of the boilers with calcium sulphate (gypsum), occurred, the operation was very irregular and many a manager of gas works, afraid to tackle this matter, rather preferred to let the gas liquor go to the sewer than endanger his and his employees' welfare and lives. Soon, however, the boards of health of the cities made an end of this nuisance, and the management was forced to get rid of the liquor in such manner that the water of the rivers was not vitiated, killing the fish, and the wells in the neighborhood of the gas works were not filled with gas liquor, that had filtered through the ground. By this time, of course, the distilling appa-

raturs were very much improved, so that the boiling of the gas liquor was no longer connected with danger, and instead yielded a handsome profit to the owners of the works. Heat naturally had to be applied in every case to drive off the ammonia, which was contained in gas liquor, and the apparatuses were constructed to use either coal, direct steam or indirect steam in heating coils. Tidy made experiments with the three mentioned means of heating and found that 7,000 gallons of gas liquor needed:

By heating with coal—22 hours giving a yield of 90 per cent of the total ammonia.

By heating with indirect steam—18 hours giving a yield of 92 per cent of the total ammonia.

By heating with direct steam—14 hours giving a yield of 98.5 per cent of the total ammonia.

Gruneberg was about the first who constructed a sectional apparatus which was heated by open fire, but

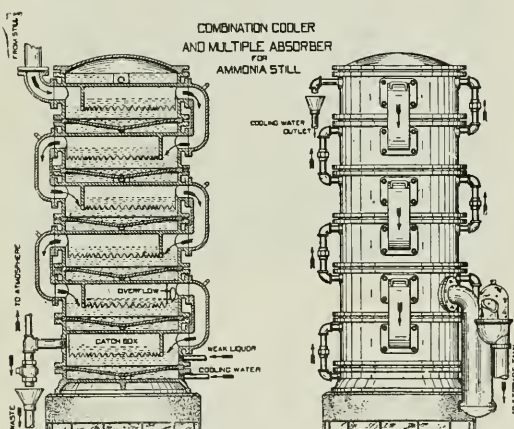


Fig. 1.

which nevertheless gave fair results; at the same time he took care that the crust of lime, which was due to the pumping of milk of lime into the apparatus to set free the fixed ammonia, could be very easily removed. A further progress in development of the ammonia industry was the apparatus constructed by Gruneberg and Blum. The applied steam, and the style of this apparatus has been the foundation on which almost every other apparatus has been built. Lack of space forbids me to go into further details of this apparatus. They are described in Lunge's "Coal Tar and Ammonia," where the full description can be found. Numerous are the types and constructions of the ammonia apparatus, which came on the market new; most of them were built to produce concentrated ammonia liquid and only a few were installed to make sulphate of ammonia. Of course, I have American gas works in mind. Here in Germany the opposite is the case. The market for sulphate of ammonia as a fertilizer is very good, and inasmuch as the process of manufacture is very simple, most of the gas works prefer to

*From the Fiftieth Anniversary Number of "The American Gas Light Journal," July 19th, 1909.

make sulphate of ammonia instead of concentrated liquor. The United States, however, with her rich soils, does not need so much artificial fertilizer, and the gas works, having good customers in large packing houses and artificial ice works, who use a good deal of ammonia in form of liquid or anhydrous ammonia, turn their gas liquor into concentrated ammonia liquor and ship it to the large chemical factories; here the liquor is distilled and purified again and the ammonia is recovered as aqua or anhydrous ammonia. Only a few gas works make aqua ammonia direct in

paratus as they are built by the different construction companies today.

Figure 1 shows a still of the Western Gas Construction Company, Fort Wayne, Ind. The gas liquor which leaves the overhead tank is preheated by the outgoing steam ammonia vapors and afterwards travels down section to section, meeting always hotter steam, which travels on the counter current principle; in the so-called volatile still, comprising the sections above the vessel called liming leg, the free ammonia, that is ammonia not bound to sulphuric, hydrochloric or nitric acid is driven off; the compounds of the ammonia with these acids must be decomposed by lime, which is pumped in in the form of milk of lime. The calcium oxide sets the bound ammonia free and this process takes place in the liming leg and the adjoining sections; leaving the lowest sections, the former gas liquor

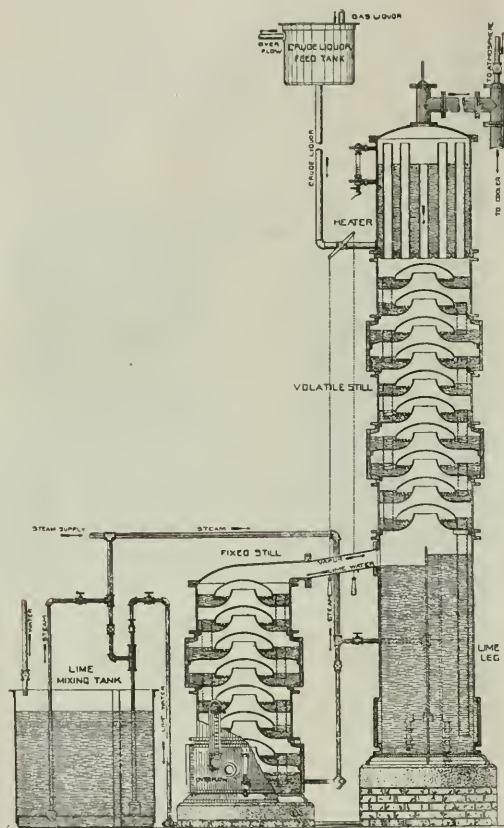


Fig. 2.

the United States. To the writer's knowledge there are only two aqua ammonia plants; one at the New Haven (Conn.) Gas Light & Coke Company, built by Messrs Bartlett, Hayward & Co. of Baltimore, and one at the Indianapolis (Ind.) Gas Company, installed by the Gas Machinery Company, of Cleveland, Ohio. I am sorry I must state again that, on account of lack of space, I cannot go into a detailed description of these plants, but it may follow in one of the later editions of the Journal. The next lines shall give a description of the most up-to-date distilling ap-

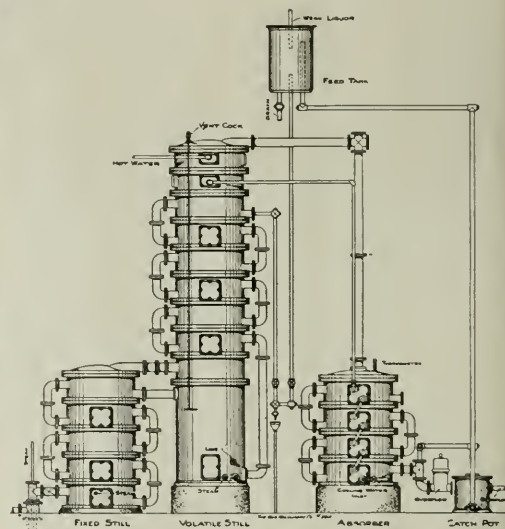


Fig. 3.

does not contain more than 0.003 per cent NH_3 . The vapors, which leave the top sections of the still are either condensed in a cooler as shown in Figure 2, and concentrated ammonia liquor containing from 16 to 18 per cent NH_3 is recovered, or they are brought into a lead lined saturator, containing diluted sulphuric acid of about 40 degrees to 42 degrees and sulphate of ammonia is recovered as end products. The saturator will be described later on.

Two similar stills, built by the Gas Machine Company, Cleveland, Ohio, are shown in Figures 3 and 4. The principle is the same as that of the Western Gas Construction Company, only the construction differs somewhat. While the still in Figure 1 has inside overflows for the gas liquor, the Gas Machinery Company very lately has arranged them outside, so that they can be cleaned very easily, in case they be blocked up with tar and other heavy matter. In Figure 4 a larger

still for the manufacture of concentrated liquor is shown. There the construction is almost identical with that in Figure 1; milk of lime, to set free the fixed ammonia, is prepared in a lime-mixer and steadily pumped into the liming leg; for smaller sizes of stills, this mixer can be spared and a steam injector may be installed, which works very satisfactorily, to pump

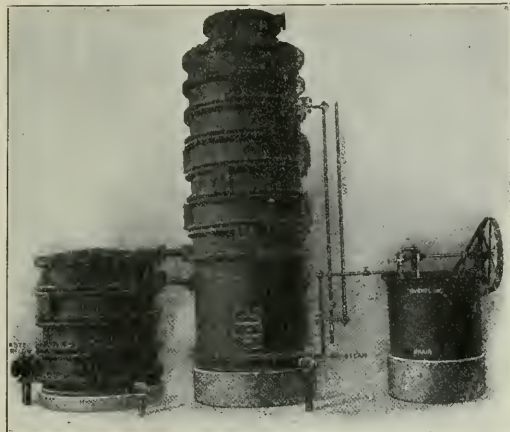


Fig. 4.

the milk of lime into the liming leg of the still. In Figure 5 an apparatus is shown which will be of interest to managers and superintendents of very small gas works. It is built and put on the market by Karl Francke, Bremen. It has the advantage that the waste liquor can be re-used again in the washers and scrubbers after it leaves the still and is cooled off. The operation of the apparatus is in short as follows: The gas liquor is filled into the wrought iron still and heated by an open fire so that the ammonia gases will leave the still on top and enter the cooler at the right hand side, where they are condensed by means of cooling water, so that a liquor of about 8 to 10 per cent strength of ammonia is obtained, which can be filled into a barrel and shipped to chemical factories, which will pay a fair price for it. In case there is an overhead tank for water, the cooling water that leaves the cooler can flow back into this tank as it will hardly take up any heat from the ammonia gases in the condenser. The waste liquor, after it leaves the still, is brought into brick basins, located outside of the building, where it cools off and later, as stated above, is used again as washing fluid in the washers or scrubbers. Of course, this waste liquor will accumulate, and in order to prevent losses of ammonia in letting it run into the sewer, part of the waste liquor is vaporized in a small steel tank. The heat to do this is furnished by the waste gases of the retorts or boilers. The percentage of fixed ammonia will thus increase in the liquor that stays in the tank: by-and-by it will be just as high in percentage of ammonia as that which

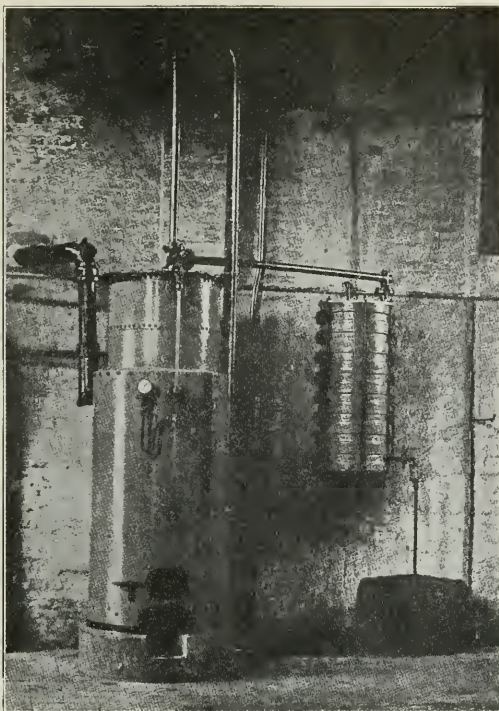


Fig. 5.

is gained in the condenser, so that the two liquors can be mixed and yet the strength of the ammonia does not decrease. In using this process, which is protected by patent, the smaller gas works have an oppor-

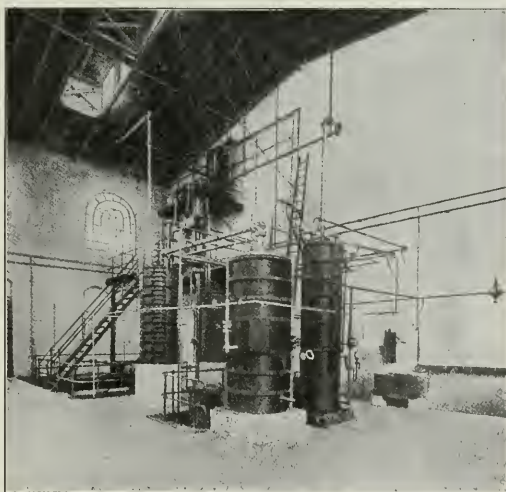


Fig. 6.

tunity to increase their net profit considerably, and this the more, as the installation of the apparatus is by no means a great expense.

In Figures 6, 7 and 8, apparatus of the Berlin Anhalter Maschinen Fabrik, in Berlin, are shown. Figure 6 represents an apparatus to work up small quantities of gas liquor into concentrated liquor. Figure 7 is the view of a concentrating plant at the city gas works in Breslau (Silesia), and Figure 8 shows the sec-

waste gases pass a lead tank in which baffle-plates are arranged to keep back as much as possible the water that is carried mechanically with the gases. In many cases these waste gases are used to preheat the raw gas liquor before it enters the still, and the saving of steam by doing so is worth while to consider. Figures 9, 10 and 11 show apparatus built by Julius Pintsch, Berlin. Figure 9 is a sulphate of ammonia plant in the Berlin city gas works; Figure 10 shows a concentrating plant

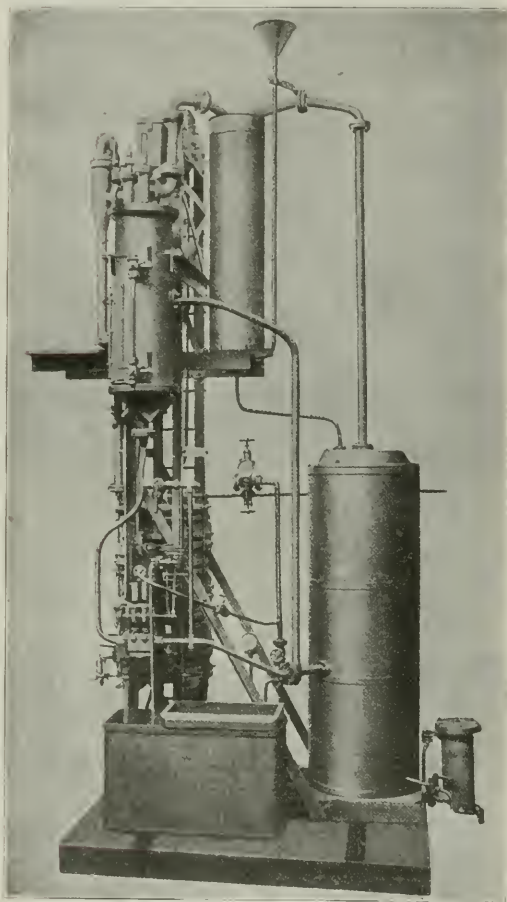


Fig. 7.

tion through a saturating box used in making sulphate of ammonia. The ammonia vapors from the still enter the box through the lead pipe, which drips into diluted sulphuric acid. To prevent the escaping of obnoxious gases into the workroom, a lead bell, G, is arranged which again is provided with a seal containing weak sulphuric acid, so any ammonia that should escape, especially when the acid is beginning to become neutral, is caught here. After this seal, the

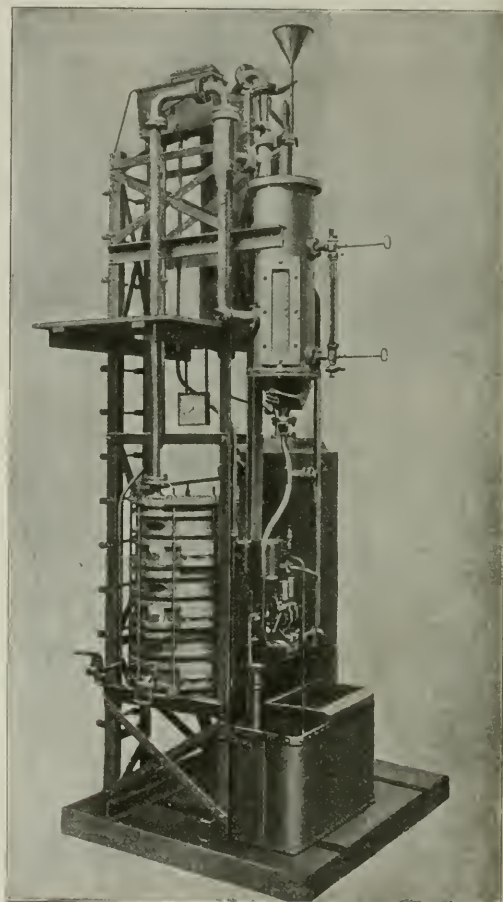


Fig. 7A.

at the city gas works in Pforzheim, and Figure 11 is an aqua-ammonia plant in the city gas works in Berlin. There are numerous other constructions yet, to describe all of which would take too much time and space, and I think the pictures which are shown give an idea of what has been accomplished in the last half-century. Especially the older gas men may make a comparison of the apparatus which they had at their disposition when they started their careers with that

which they have in operation now. Many of them may have helped in their way to bring the ammonia business to the standard of today, which, as stated in the beginning, yields the gas companies a fair profit and helps pay the heavy expenses which the gas in-

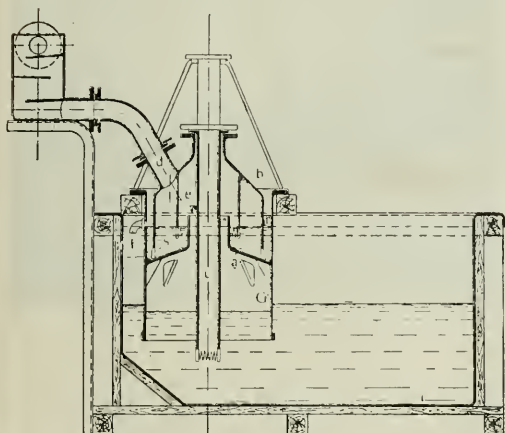


Fig. 8.

dustry has to meet in our days. The following tables give the operating expenses, gross and net earnings for ammonia plants making concentrated liquor 16 to 18 per cent. NH_3 , high concentrated liquor 25 to 30 per cent NH_3 , sulphate of ammonia, aqua ammonia and anhydrous ammonia. The figures are given on German basis, but in taking the prices and figures, which are paid in the United States one can easily figure out what he may gain by installing this or that kind of an ammonia plant.

Pos.	Definition.	Concentrated liquor 16— 18% NH_3 .	Concentrated liquor 25— 30% NH_3 .	Sulphate of ammonia.
Expenses.		Mks.	Mks.	Mks.
1.	Interest and amortisation (5 + 2 per cent) for the buildings = 7 per cent of the capital of marks 2,500	175	175	175
2.	Interest and amortisation of the apparatus with all necessary machinery (5 + 10 per cent) for concentrated liquor of 16 to 18 per cent. NH_3 = 15 per cent of the capital, marks 6,000	900	...	...
3.	Interest and amortisation of the apparatus with all necessary machinery (5 + 10 per cent) for concentrated liquor of 20 to 30 per cent = 15 per cent of the capital, marks 7,000	...	1,050	...
4.	Interest and amortisation of the apparatus with all necessary machinery (5 + 10 per cent) for sulphate of ammonia = 15 per cent of the capital marks 7,000	...	...	1,050
5.	Fuel for boilers. For driving off carbonic acid and distilling 1 cbm. of gas liquor = (264 gallons) about 450 pounds of steam are			

used; consequently for 1,500 cbm. = 675,000. To produce this steam, about 43 tons of coal are needed. Figuring the ton with marks, 20, then the fuel amounts to	860	860	860
6. Lime to decompose the so-called fixed ammonia compounds. Supposing the gas liquor contained 0.36 per cent fixed N_2 , H_2 , c. the fifth part of the total ammonia (1.8 per cent), then 264 gallons of gas liquor would need about 20 lbs. of lime, consequently for 1,500 cbm. or 396,000 gallons = 30,000 lbs. Figuring the ton of lime stone with 16 marks, then the expense for lime would be	192	192	192
7. Cooling water for the coolers. For cooling purposes about double the amount of the gas liquor, which is worked up, will be used, consequently 792,000 gallons. Figuring 1 cbm. = 264 gallons with 0.05 marks we get	150	150	150
8. Sulphuric acid for binding the ammonia. Gas liquor of 1.8 per cent NH_3 contains in 1,500 cbm. 60,750 lbs. of NH_3 . About four times of this amount will be needed on sulphuric acid, having 60° B.; making a total of 243,000 lbs. of acid. Figuring 100 Kg. or 225 lbs. of acid with marks 4.50, then 243,000 lbs. will cost			4.86
9. Wages for laborers. The yearly production of 1,500 cbm. gas liquor can be worked up in 150 days. For each day one laborer is needed, getting marks 4.50 per day; the total wages would be	1,350	1,350	1,350
10. Expenses for repairs and breakable parts	50	50	50
11. Expenses for packing waste, oil, illumination of the work room, taking away of the lime residuals, etc.	150	150	150
Total expenses	3,827	3,977	8,837

Receipts.

1. 1,500 cbm. of gas liquor, containing 1.8 per cent NH_3 , yield about 150 tons of concentrated liquor having about 18 per cent NH_3 . Figuring one ton with about marks 144 (containing 180 Kg. NH_3) then we get	21,600	...	...
2. 1,500 cbm. of gas liquor containing 1.8 per cent NH_3 , yield about 108 tons of concentrated liquor having 25 per cent NH_3 . 1 ton, containing 250 Kg. NH_3 , is paid with marks 205, so we get a total of.	...	22,140	...
3. Sulphate of ammonia gives about the same weight as sulphuric acid is used, i. e., 108,000 Kg. (= 243,000 lbs.) 100 Kg. of sulphate ammonia are paid with marks 24. for 108,000 Kg. we receive	...	...	25,920
Total receipts	21,600	22,140	25,920
Deducting 2 per cent unavoidable losses on ammonia	450	450	450
Leaving receipts	21,150	21,690	25,470
Recapitulation.			
1. Total receipts	21,150	21,690	25,470
Total expenses	3,287	3,977	8,837
2. Leaving a surplus of marks	17,863	17,713	16,633
Figuring the value of the gas liquor, which may have been sold before at marks 0.25, we deduct from this surplus	6,750	6,750	6,750
Leaving a net profit of marks	10,573	10,963	9,883

OPERATING EXPENSES FOR PLANTS WORKING ON CONCENTRATED LIQUOR AND SULPHATE OF AMMONIA.
The contents of NH_3 in the gas liquor is supposed to

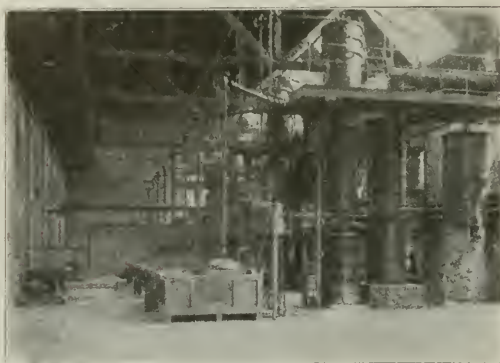


Fig. 9.

be 1.8 per cent; it is presumed that there is a boiler to produce the necessary steam, so that it is not necessary to install a special boiler.

For figuring 1,500 cubic meters of liquor are taken, which can be worked up in 150 days.



Fig. 10.

OPERATING EXPENSES FOR PLANTS WORKING ON TECH-
NICALY AND CHEMICALLY PURE AQUA AND AN-
HYDROUS AMMONIA, CONTAINING

99.9 PER CENT NH_3 .

Daily capacity, 20 cbm. (= 5,280 gallons) gas liquor

containing 1.8 per cent NH_3 . It is presumed that a boiler is installed, to produce the necessary steam. The

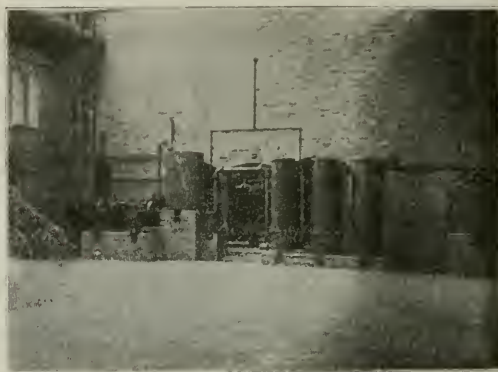


Fig. 11.

figures are based on 3,000 cbm. gas liquor, which are worked up in 150 working days.

Aqua Ammonia.

Pos.	Definition.	Technical pure.	Chemical pure.	Anhydrous ammonia
		Mks.	Mks.	Mks.
1.	Interest and amortisation for the buildings (5 + 2 per cent) amounting to 7 per cent of capital of marks 4,000.....	280	280	280
2.	Interest and amortisation for the apparatus for technical pure aqua ammonia (5 + 10 per cent) amounting to 15 per cent of the capital of marks 16,000.....	2,400	...	...
3.	Interest and amortisation for the apparatus for chemical pure aqua ammonia (5 + 10 per cent) = 15 per cent of marks, 1,000.....	...	2,400	...
4.	Interest and amortisation for the apparatus for anhydrous ammonia (including 500 steel cylinders at marks 45) 5 + 10 per cent = 15 per cent of cent 44,000 marks....	...	...	6,675
5.	Fuel for boiler. For eliminating carbonic acid and heating 1 cbm. gas liquor 250 Kg. steam are consumed; consequently for 3,000 cbm. = 750,000 Kg. of steam. To raise this steam 107,000 Kg. coal are needed. Figuring marks 2 for each 100 Kg. we get.....	2,140	2,140	2,140
6.	Lime for decomposing fixed ammonia compounds and binding carbonic acid. For each per cent and weight, 12 Kg. good lime are used; one cubic meter gas liquor containing 1.8 per cent NH_3 therefore needs 21 Kg. 100 Kg. lime are paid with marks 1.60; 6,300 Kg. then will cost.....	1,008	1,008	1,008
7.	Cooling water. For cooling purposes almost four times the quantity of the gas liquor is used = 12,000 cbm., 1 cbm. costing marks 0.05, we get.....	600	600	600
8.	Cooling water for the ammonia compressor. About double the quantity of the gas liquor must be at disposition. Figuring 1 cbm. with marks 0.05 =.....	...	...	300

9. Consumption of sodium hydrate.

This depends a good deal on the carefulness of the operator. Usually $\frac{1}{2}$ Kg. is used for technical pure aqua ammonia and double the quantity for chemical pure aqua ammonia and anhydrous ammonia per cubic meter of gas liquor. We therefore need 1,500 resp. 3,000 Kg. of sodium hydrate. 100 Kg. of 75 per cent NaOH cost about 22 marks; therefore 1,500 Kg.

330 660 660

10. Bone black filters. Bone black of

pea size. In making technical pure aqua ammonia 1 Kg. bone black per cubic meter gas liquor is needed. For making chemical pure aqua ammonia and anhydrous ammonia, 2 Kg. are required. The price for 100 Kg. being marks 28, we have for 3,000 Kg.

840 1,680 1,680

11. Wages for laborers. The yearly

production of 3,000 cbm. is worked up in 150 days. For each day (24 hours) 4 men are needed, each earning marks 4.50. In 150 days the total wages would be...

2,700 2,700 2,700

12. Expenses for repairs and break-

able parts

150 150 150

13. Expenses for packing material,

waste and oil, illuminating of the working rooms, taking away the lime residuals, etc.

450 450 450

Total expenses 10,898 12,068 16,643

Receipts.

1. 3,000 cbm. gas liquor will yield 216 tons technical pure aqua ammonia, containing 25 per cent NH_3 and a spec. gravity of 0.91. 1 ton is paid with marks 275, so we get

59,400

2. The same amount as above will be recovered as chemical pure aqua ammonia, paying 312 marks a ton, which would be

67,392

3. As anhydrous ammonia 54,000 Kg. can be produced, paying about 1.50 marks per Kg., amounting to

81,000

4. Deducting 3 per cent for unavoidable loss on the ammonia. Would give a total receipt of marks

2,200 2,200 2,200
57,200 65,192 78,800

Recapitulation.

1. Total receipts, marks

57,200 65,192 78,800

2. Total expenses 10,898 12,068 16,643

3. Leaving a surplus of 46,302 53,124 62,157

4. Deducting the value of the gas liquor (1 Kg. $\text{NH}_3 = 0.25$ marks) with

13,500 13,500 13,500

..... Gives a net surplus of 32,802 39,624 48,657

A simple method of fireproofing textiles, recommended in 1899 by the Paris board of fire commissioners, consists in steeping the materials in a 10% solution of phosphate of ammonia, after which they are wrung out and placed to dry in the open air. The cloth is rendered a trifle stiff, but when exposed to the action of a flame it blackens without taking fire. This method is particularly appropriate for the flimsy material worn in certain religious ceremonies, at balls, theaters, etc.

Horse Power from Different Coals

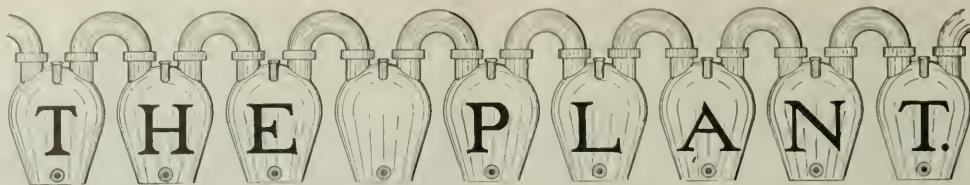
The following table is from Bulletin 373, U. S. Geological Survey, on "The Smokeless Combustion of Coal in Boiler Plants. On the assumption that the boilers at the average good plant are run at approximately the same efficiency as those at the government testing plant, the figures given in the table for coal per boiler horsepower per hour may be used as a basis for an approximate determination of the total boiler horsepower hour at any plant. This is done by simply dividing the amount of coal used per hour by the figures in the table opposite the state from which the coal is supplied. For instance, a consumption of 460 lbs. of best Illinois coal per hour indicates that the total boiler horsepower developed would be about 100.

Coal per
H. P. Hour.

State—	Lbs.
Alabama	4.2
Arkansas	3.9
Colorado (lignite)	6.0
Illinois (best)	4.6
Illinois (fair and poor)	5.0
Indiana	4.7
Indian Territory	4.5
Iowa	5.5
Kansas	4.4
Kentucky	4.0
Maryland	3.8
Missouri	5.1
New Mexico	5.5
Ohio	4.2
Pennsylvania	3.6
Virginia	3.7
West Virginia	3.6
Wyoming (lignite)	6.1

Assay Instructions Must Be Sent Separate from Sample.

The postmaster of El Paso, Texas, held up samples of ore addressed to the local assayers on the grounds that they should pay first-class sealed letter rates of 2 cts. per ounce, instead of 1 ct. per ounce, as they had been doing for over 30 years, on the basis of fourth-class matter. The reason for this change is that there is a line on the outside of each sample sack used in mailing with the printed words: "Assay for." The shipper would fill in this line with words "silver, lead, gold," or whatever metal he wished determined. If but one word is written on the envelope, although unsealed, first-class sealed letter rates must be paid. The local assayers complained that it was an undue hardship not alone on the miners and prospectors, but the assayers as well, that this 1-ct. rate had been in vogue for a third of a century not alone in the United States but in Mexico. Arguments were useless, as the department has decided against the 1-ct. rate, and 2 cts. per ounce must be paid in the future or else samples will be held up, unless instructions are sent by separate letter or postal card.



THE MECHANICAL PREPARATION OF SOLIDS FOR CHEMICAL TREATMENT—GRINDING.*

Written for The Chemical Engineer.

(Continued from the June issue.)

A form of crusher which is extensively used instead of rolls to reduce the product of the large gyratory crushers to material which will pass a one-inch screen, is the toothed or corrugated spindle crusher. This is made in a number of forms and by almost every manufacturer of crushing machinery. The simplest form is what is commonly known as a "pot" crusher or "coffee-mill cracker." This works on practically the same principle as a coffee mill. It is shown in Fig. 10. The grinding is done between corrugated surfaces. The spindle revolves between fixed bearings, one in

which, as it is reduced, falls to the lower part of the mill, where the grinding surfaces have a finer corrugation and are set closer together. These mills are extensively used in chemical works for reducing moderately hard substances where these do not pack fast in the corrugations. The mills are also suitable for grinding shale, gypsum, coal and other substances which choke up the gyratory crusher.

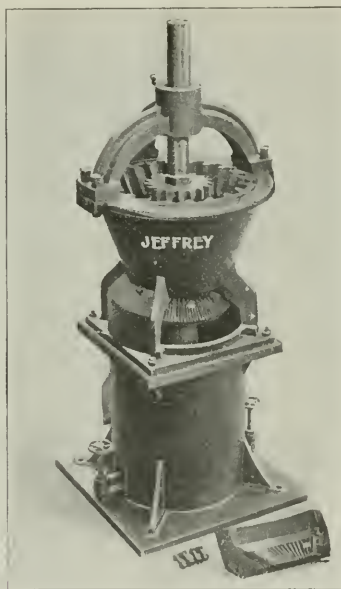


Fig. 10.—Patent Crusher (Jeffrey Mfg. Co., Columbus, O.).

the spider and one on the base of the mill. There is no eccentric motion, as in a gyratory crusher, and the grinding is done between the V-shaped corrugations on the spindle and hopper plates. With this form of crusher the upper part or hopper receives the material.

*This is the fourth series of articles upon the Elements of Chemical Engineering. Former articles treated of the Materials of Construction, Storage of Materials, Conveying Materials, and Weighing and Measuring Solids, Liquids and Gases. The next series will be upon drying.

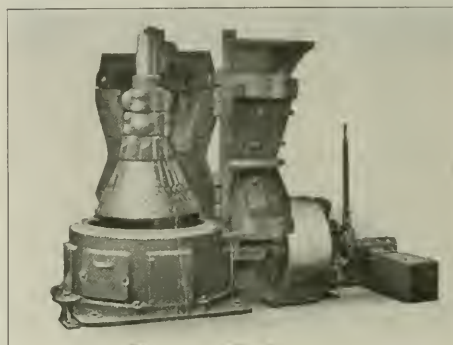


Fig. 11.—Open Door Crusher (Sturtevant Mill Co., Boston.).

An improvement on the ordinary pot crusher is the open door crusher, shown in Fig. 11, made by the Sturtevant Mill Company, of Boston. The construction of this mill is evident from this cut. Upon the central shaft of the crusher are located a number of crushing heads. The upper ones are provided with knobs and are set some distance from the side plates of the crusher so as to reduce the largest material. The lower heads are shaped like an inverted cone and are provided with fine corrugations and set near the sides of the crusher, the distance lessening as the bottom of the cone is reached. This crusher has the advantage that the interior is easily accessible for replacements and inspection. It is also mechanically a much better crusher than the simple pot crusher, more economical of power and may be made to give finer and more uniform product. It is also naturally a slightly more expensive machine.

Granulators or Disintegrators.

A number of mills may be considered as strictly granulators and disintegrators rather than crushers or pulverizers. Some pulverizing mills may, of course, be used as disintegrators, and nearly all disintegrators are used in connection with some form of separator, such as a screen, to pulverize. Among the best known disintegrators are the ball mill and the komimuter,

which is a modification of the ball mill, the cage disintegrator and the hinged or fixed hammer mill. These three mills all work upon a different principle.

The ball mill is of European origin and was used for grinding in Germany before its introduction into this country. It is usually used in connection with the tube mill to prepare the material for the latter.

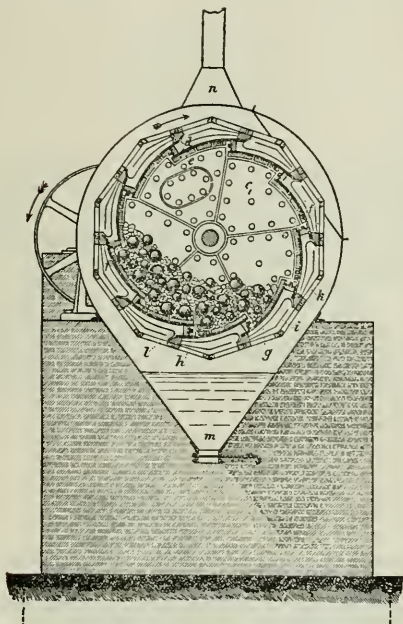


Fig. 12.—Ball Mill, Section Showing Grinding Plates and Sieves (F. L. Smidth & Co., New York).

the ball mill reducing it to a coarse grit and the tube mill completing the operation.

Figs. 12 and 13 show the construction of a ball mill. It consists of a drum filled with steel balls. The drum is lined first with steel plates (d), which lap one over the other to form steps. As the drum revolves, the balls drop over the steps pounding the material to pieces. The partially ground material then drops through holes in the plates on to perforated steel screens (g) bolted around the entire circumference of the drum. These screens take out the very coarse particles and return them to the inside of the drum. The finer ones drop on another set of screens (i) made of woven wire cloth, and these separate the fully ground material from the coarse and return the latter back to the mill.

The fully ground material falls into the dustproof casing, which entirely surrounds the mill, and then down to the conveyor, running underneath the latter.

The ends of the drum are formed by circular plates. In the Gates and Krupp forms of this mill and also in the smaller size of the Smidth mill these plates have rigidly attached to their centers, hubs which are mounted on to a heavy shaft which revolves in dustproof

bearings. One of the hubs is provided with openings through which the material to be ground is fed. In the large size Smidth mills the shaft is omitted and the hub rests on roller bearings, giving a full circular opening which will admit of the passage of lumps 10 inches in diameter into the mill. The feeding device of the Smidth mills consists of a circular revolving table provided with a scraper. The material to be ground is brought down upon the table by a spout which stops short a few inches from the former. As the table revolves, the material flows out of the spout upon it and as it comes around to the scraper is brushed off into the hopper of the mill. The feed can be regulated by adjusting the scraper so as to brush off a greater surface of the table. The Gates ball mill has a swinging feeder.

The size of the product of the ball mill is regulated entirely by the fineness of the finishing screens. Those on mills intended to grind material for a tube mill to finish are usually 16 to 20 meshes to the linear inch. It is generally economy to so balance the screens as to get the most out of the tube mill, however, since the ball mill requires much less power than the tube mill and consequently up to a certain point should be made to do all the work it will. The screens of the ball mill are apt to leak occasionally, both from wear

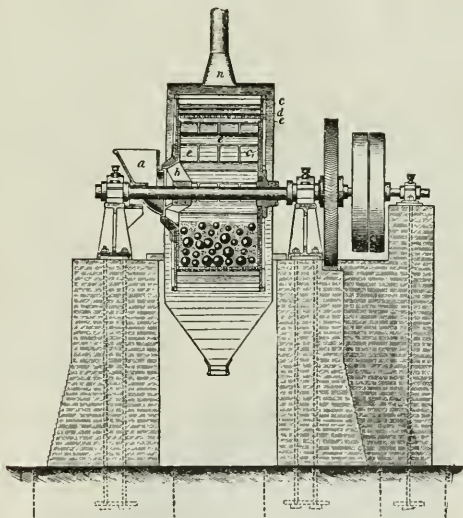


Fig. 13.—Ball Mill, Section Through the Shaft (F. L. Smidth & Co., New York).

and also from the dropping out of a rivet or bolt. A good check upon this is to run sieve tests of the product upon a No. 20 sieve once or twice a day and any abnormal weight of residue should be followed by an examination of the screens for leaks. It is necessary to brush the screens off occasionally with a wire brush, as they clog with use.

A ball mill usually requires from 30 to 40 horsepower and turns out from 4 to 6 tons of material per

hour. The balls run in sizes from 3 to 5 inches in diameter and the charge of balls for a mill of the above size weighs usually about a ton and a half.

The Ball mill is an expensive machine and hence only suited to large operations. A No. 7 mill costs about \$2,800 and a No. 8 mill \$3,500.

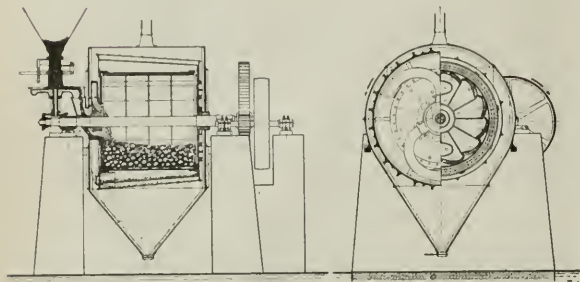


Fig. 14.—Kominuter (F. L. Smidth & Co., New York).

Ball mills are now often employed without screens instead of rolls and pot crushers to prepare material for final reduction in such mills as the Fuller-Lehigh and Griffin.

Ball mills are sometimes used for fine pulverizing. They are not economical pulverizers, however, and are usually only used for this purpose where small quantities are to be ground. When required to do this, they are screenless, the plates are not perforated, and the material is not fed into them in a regular stream. On the other hand, the charge of balls and material to be ground is placed in the mill by means of the manhole, which is then closed, and the drum is revolved until the material is of the necessary fineness. Such a ball mill can be employed for grinding either dry or wet substances. A grid to be placed over the manhole when the cover is removed allows the charge to be dumped without removing the balls.

A modification of the ball mill which has been introduced in the last three years by Messrs. F. L. Smidth & Co. is the Kominuter. This form of mill is intended

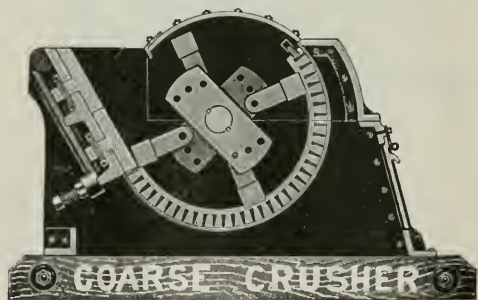


Fig. 15.—Hinged Hammer Mill (Williams Patent Crusher & Pulverizer Co., Chicago).

to do the work of the ball mill and has about double the capacity of the latter. It consists (Fig. 14) of a

drum of about the same diameter as a ball mill, but of about twice the length of the latter, suspended on a shaft supported by bearings. The kominuter is lined just as is a ball mill with wrought iron or steel grinding plates arranged to lap and form steps. The drum is surrounded by a coarse screen tilting slightly towards the feed end, and outside of this screen is yet another one of wire cloth. The material enters through an opening beside the shaft and is pounded to pieces by the balls. It does not fall out through the screens, however, at once, but travels through the full length of the drum and passes through openings at the opposite end, on to the first coarse screen, or perforated plate. The particles too large to pass through this are returned automatically to the interior of the mill by means of buckets and S-shaped pipes. The material passing the inside screen is caught upon the outside one of wire cloth and separated further here, the coarse material being returned to the mill as before. The kominuter requires about 40 horsepower.

The hammer mill is made in a number of forms, each maker having his own type of mill and peculiarity of construction. In some the hammers are fixed and in some hinged. The form shown in Fig. 15 is the Williams mill. This is one of the best types of granu-

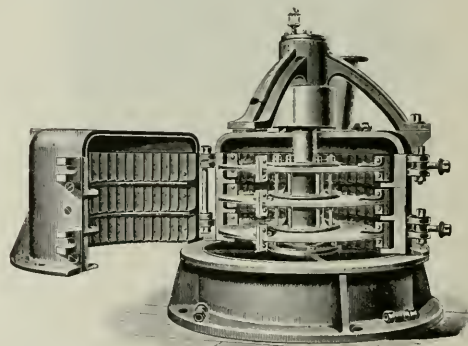


Fig. 16.—Abbe Mill or "Max" Mill (J. R. Alsing Co., New York).

lator. This consists of a number of hinged hammers, which revolve around a horizontal shaft. These crush the material and pass it out through a grid screen as shown in the cut. The mill as now made is provided with an arrangement by which the grinding plates can be moved nearer the hammers, by means of a hand wheel on the outside, to allow for the wear of the hammers.

By the employment of hammers which are shaped so as to cut, mills of this type have been adapted to the reduction of a large variety of soft materials such as wood waste, soap, beef scrap, oil cake, etc.

A somewhat similar mill is made by the Jeffrey Manufacturing Co., of Columbus, O., and still another type has rings in place of hammers. These hinged hammer machines are economical and are used exten-

sively for the grinding of such material as limestone, gypsum, shale, slate, phosphate rock, fire clay, kaolin and coal. A mill similar in action to the Williams and Jeffrey mills has the shaft vertical and the hammers revolve in a horizontal plane. Such a mill is the well-known "Max" mill (Fig. 16). With mills of this latter type, however, the object is rather to disintegrate the material by centrifugal action rather than by the

mills depend for their action upon a number of principles. Thus in a stamp mill the material is crushed by percussion or the direct flow of the stamp upon it, while with buhr stones the material is ground by attrition or the rubbing of the material on itself or the stones. In Chilean mills, dry pans, etc., the action is merely a crushing one in which the weight of the rollers overcomes the crushing resistance of the material. In most modern pulverizers, however, the last two principles are combined. Thus in a Fuller-Lehigh mill the action is not only one of rubbing, but there is also a direct crushing action due to the centrifugal force with which the balls are pressed against the die. This combination of the two forces usually results in a very fine product and great economy. It also allows a more variable feed, as the crushing force takes care of the large pieces and the rubbing reduces the fine ones to a still smaller state of subdivision.

Practically all pulverizer mills consist of two parts: the crushing system and the separating or screening system. The single exception being a tube mill which needs no separating system and in which the fineness of the product is regulated by the fineness of and the rate at which the material is fed into the mill. Practically all separating systems are of the air type. In some mills screens are also employed, but this is usually done merely to control the draft of air. With some mills the separator and mill are entirely separate, while in others the two are mounted on the same base, making very compact pulverizing units. Mills of this

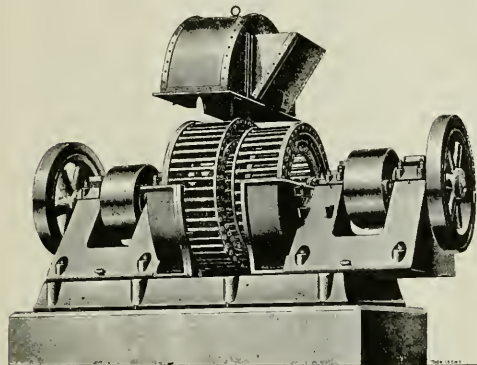


Fig. 17.—Cage Disintegrator (Stedman's Foundry & Machine Works, Aurora, Ind.).

hammer. The material to be ground is fed on to revolving discs which throw it out against the grinding plates. In the form of mill shown (manufactured by The J. R. Alsing Co., New York) the material drops from one disc to the next. These disintegrators are used extensively for the grinding of such materials as spices, herbs, and drugs, and in fact may be employed for any medium hard material which is not sticky, and even for damp material.

The Steadman Cage Disintegrator is a mill of the centrifugal type and consists of two or more circular rings studded with beaters, as shown in Fig. 17. These beaters form a cage. This cage revolves within and in the opposite direction from another cage. The cages revolve at a peripheral speed of about 150 feet per second and about one-half the power is consumed in moving air within the casing and overcoming the friction of the machine. The cages are driven by means of two shafts with pulleys, one of which latter is rotated by a quarter-turn belt, so that the cages revolve in opposite directions. These disintegrators are made in a number of sizes and are very useful for pulverizing such substances as superphosphate, coal, soda ash, salt cake, etc., which would form pasty masses and clog up the grooves or corrugations of ordinary mills. The machine requires careful lubrication and repairs are fairly heavy.

A 36" cage disintegrator requires about 30 horsepower and will have a capacity of about 5 tons of phosphate rock per hour. A disintegrator of this size may be obtained for about \$450.

Pulverizers.

A large number of mills for the reduction of substances to a fine powder are upon the market. These

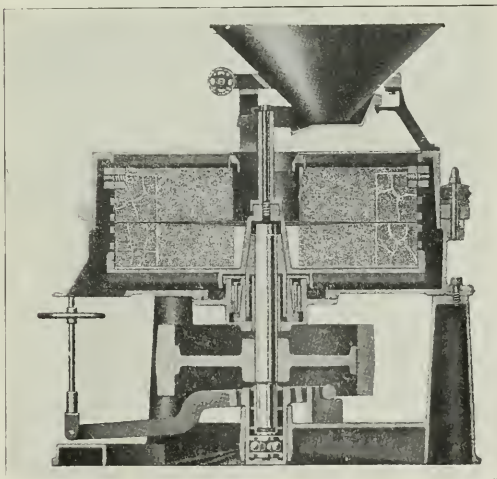


Fig. 18.—Emery Mill (Sturtevant Mill Co., Boston).

type are now generally preferred for pulverizing on a large scale, as, for example, in cement manufacture.

Perhaps the oldest type of fine grinding mill is the ordinary buhr-stone mill, familiar to every one and employed in small flour and grist mills. This form of mill is still used extensively in the chemical trade as well. It will probably deal with a larger variety of

material than any other form of mill and may be used for either wet or dry material. It is necessary, however, to lubricate the running parts of the mill thoroughly and to keep the mill stones well dressed.

Fig. 18 shows a type of buhr-stone mill which is extensively used in the chemical and paint trades. The mill stones are dressed in grooves or furrows, so that

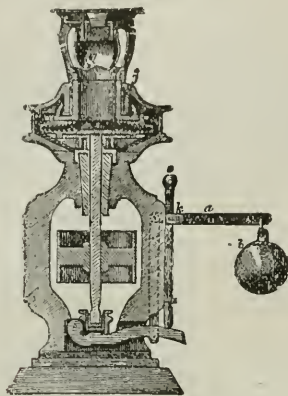


Fig. 19.—Eccentric Bogardus Mill (John Acton, Brooklyn, N. Y.).

when they are lying with their faces upwards, the grooves run in similar directions. When the upper stone, however, is reversed on the lower one, the direction of the grooves is also reversed and the edges will meet when running, after the manner of a pair of shears. The grooves are cut perpendicularly into the stone on one side, the bottom of the groove forming an inclined plane on the surface of the stone to its full depth across the width of the groove. This gives each furrow a sharp edge which must be kept in this condition if the mill is to grind economically. The material is fed into the mill at the center and drops out at the sides. The lower stone is revolved by means of a central shaft, and the upper stone is balanced upon the lower one. This balancing must be perfect. This is accomplished by means of shifting weights.

A cheap grinding machine, somewhat on the order of the mill stone has two steel discs in which a series of eccentric rings are cut. These discs or plates are mounted on the center and revolve eccentrically at the rate of from 600 to 800 revolutions per minute. Fig. 19 shows such a form of eccentric mill. It has been extensively used in this country in the chemical trade. Owing to the cutting action of the mill, it is suitable for such substances as asbestos, cork, fish-scrap, horn, leather, etc.

The U. S. Geological Survey and Forest Service have collected statistics which show that the annual consumption of round mine timbers exceeds 165 million cu. ft., and that hardwoods constitute more than half the total.

A LIQUID METER.

The illustrations (Figs. 1, 2 and 3) accompanying this sketch show a liquid meter, designed by Mr. W. Leinert, which has found extensive use in measuring water, petroleum, sugar juice, spirit, acids, oil, etc.

The measuring is done by weight and not by volume, and therefore the results of the measuring are not affected by ordinary changes of temperature. The meter is simple, having few movable parts to wear or get out of adjustment, furthermore it is not injured by grit and impurities, and it can be readily cleaned and sterilized. The meter is not influenced by the pressure of the inflowing solution and is, of course, not open to objections commonly made to volume meters, such as the effect of friction, leakage past pistons, variation of volume due to temperature, etc.

The apparatus consists of two tanks of equal size—see A^1 and A^2 , Fig. 3—which work on edged prisms B, around axes which divide the tanks into two unequal parts. Each tank is fitted at one end with a syphon pipe C, and at the other with weights D. The liquid to be measured flows through the pipe E, passing along the gutter F into either tank, for instance as shown in Fig. 3 into the left hand tank A^1 .

The weights D are so adjusted that until the tanks are filled with the liquid up to the height marked G,

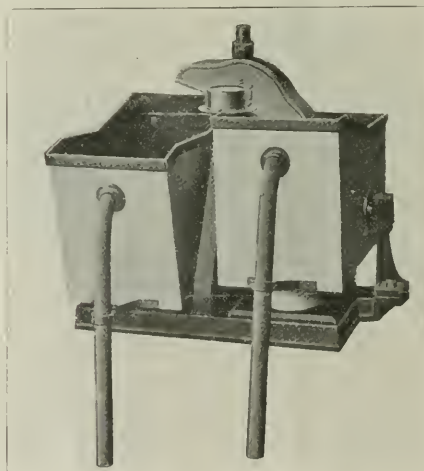


Fig. 1.—Leinert's Liquid Meter.

Fig. 2, they remain in a horizontal position, but as the liquid rises above that point by the continued flow, the tanks come into the position as shown by the dotted lines in Fig. 2, when the liquid flows through the syphon pipe. After the syphon has been started and the level of the liquid in the tank has fallen sufficiently, the tank tilts back again to its original position, by the influence of the weight D, the syphon continuing in action until the tank is emptied. As each tank assumes the position (indicated by the dotted

lines Fig. 3) it suddenly tilts the gutter F over, so that the new liquid to be measured is obliged to fall into the other tank, when the same operation as already described is repeated. It will thus be seen that both tanks are filled automatically with fresh liquid, while the measured liquid runs away into a reservoir or other receptacle as required.

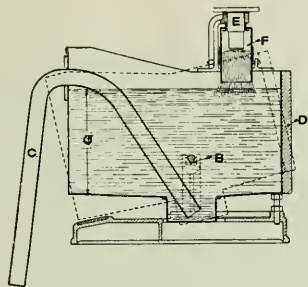


Fig. 2.—Side View.

The number of times each tank is filled and emptied is registered by the indicator H, which is connected with both tanks. When either tank is in a horizontal position, the gutter F rests upon the support J, which is of saddle form, therefore when the tank is at the moment of tipping no influence can be exercised either by the weight of the gutter or by the pressure of the running of the liquid in the gutter, or by the resistance in the mechanism of the counter.

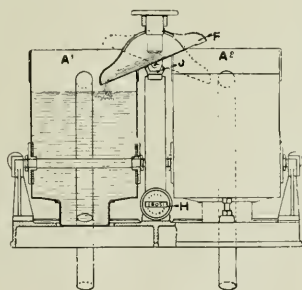


Fig. 3.—Front View.

It should be noted that the tilting of the tanks (and consequent recorded measurement) is entirely dependent upon the introduction into them of a definite weight of liquid, irrespective of variations in volume due to specific gravity, or ordinary variations in temperature.

The meters are made in a number of sizes ranging in capacity from 30 to 2,000 pounds per minute, and even larger sizes can be obtained for special purposes.

The value of the mineral output of the Transvaal for the first half of 1909 was £16,723,785, of which gold amounted to £15,472,409, and diamonds £580,807.

SULPHURIC ACID LEAD CHAMBER CONSTRUCTION¹

By **FREDERIC J. FALDING,**

Consulting Chemical Engineer, 55 Broadway, New York.

The first sulphuric acid chambers were merely lead boxes into which weighed quantities of sulphur and nitrate of soda were introduced and burned in the presence of water vapor. After reaction of the gases and the formation of sulphuric acid was complete, a new charge was introduced, the process being entirely intermittent.

At a later date the sulphur and niter were burned in special apparatus distinct from the chambers, and the

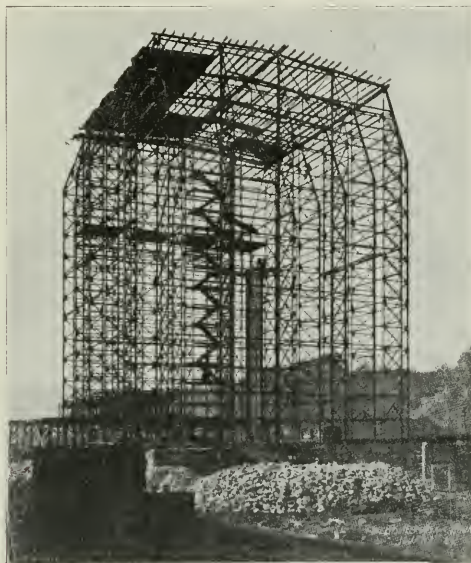


Fig. 1.—Steel Framework at Vandergrift, Pa.

resulting burner gas was carried to a series of such lead boxes, sufficient in number and capacity to permit the reaction of the gases and to secure their more or less quantitative conversion into sulphuric acid before the discharge of the residual gases into the air. This involved a continuous admission of burner gas (sulphur and nitrogen oxides, nitrogen and oxygen) and water vapor and a continuous discharge of the residual gases at the exit. No attempt as yet was made to recover the nitrogen oxides.

Gay Lussac towers were added at the exit in 1827 to accomplish the saving of the nitrogen oxides by means of their absorption in strong sulphuric acid and in 1859 the Glover tower was interposed between the burners and the chamber system to effect the partial cooling of the burner gas and concurrently the partial concentration of the weak chamber acid by means of

¹Engineering and Mining Journal, Sept. 4th., 1909.

the heat so abstracted together with the denitration of the nitrous vitriol produced in the Gay Lussac towers and the return of the nitrous oxides to the circulation of the chamber process.

The chambers have always been simply a series of enlargements of the flue or gas conduit connecting at first, the sulphur burners with the outer air or exit and later, the Glover and Gay Lussac towers. These enlargements of the flue retarded the speed of the gasses, permitting them to mingle and react.

The principle dimension of the chamber space has always been the horizontal axis in the same direction as the travel of the gas. As the chambers have been almost universally framed with wood construction, the height and width have varied principally in conformity with considerations of carpentry—a width

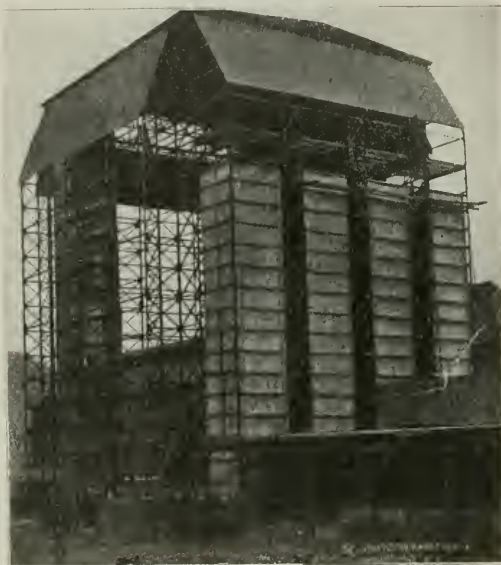


Fig. 1.—Partially Completed Chambers and Towers at Vandergrift, Pa.

of 30 ft. and a height of 24 ft. having been rarely exceeded, whereas a length of 100 to 200 ft. or over, for each chamber used to be quite common. Lead chambers have been constructed empirically and of all shapes and sizes but always of greatest length on the horizontal axis. Sometimes the gas would pass through from 4 to 10 chambers in series, having a total length of from 400 to 1,000 ft. in all.

FACTS ABOUT CHAMBER REACTIONS.

The gas mixture on its first entrance to the chambers from the Glover tower is better fitted, in every respect, to react rapidly than it will be at any subsequent stage of its passage toward the exit. It is richer in SO_2 at this point and as it passes forward through the chamber system it becomes poorer in SO_2 and more and more dilute and the reactions become rapidly more sluggish and less intense.

It is an admitted observation that irrespective of the length of the first chamber of a series, all the active work of such chamber is performed within the first 30 to 40 ft. of its length and that the remainder of the chamber is practically inactive and reaction is not resumed until the gas has again been mixed and probably dried and cooled by passing through a comparatively small flue or special cooling apparatus in the nature of a surface or spray condenser, with a new zone of activity is induced in a succeeding chamber, the condition existing in the first chamber being reproduced, but in a lesser degree of intensity, due to the diminished percentage of the sulphur dioxide content of the gas and evidenced by a reduced temperature of the active zone. The same conditions with increasing reduction of activity apply to all subsequent chambers of the series until the absence of sulphur dioxide in the final chambers sometimes actually permits the conversion of the nitrous gases into nitric acid and peroxide, causing severe losses of niter and rapid destruction of the lead. It has been the practice in some cases to admit a fresh supply of burner gas into the last chamber to counteract such conditions.

Now, just as in the old days of the intermittent process, providing a quantitative mixture of sulphur dioxide, oxygen, nitrous oxides and water vapor is introduced into a lead-lined chamber of sufficient size and the conditions are such as to prevent any mechanical interference, a quantitative reaction or series of reactions will rapidly take place.

It is quite easy to understand how in the horizontal system of flue enlargements or chambers such a quantitative reaction can be interfered with mechanically, as evidenced by the common case of the "loss of process" by a sudden storm or other meteorological conditions when the gas body has been pulled forward in the chambers by a sudden increase in suction at the exit until the sulphur dioxide not converted into sulphuric hydrate at the proper part of the chambers is carried into the Gay Lussac towers and the niter recovery interfered with to such an extent that the gas mixture at the beginning of the process does not contain its proper proportion of nitrous compounds. The same pull toward the exit affects the normal chamber process, but in a lesser degree, and prevents the quantitative reaction taking place in the first chamber where all the necessary ingredients are best balanced and where such quantitative reaction should naturally take place.

Various attempts have been made to secure a quantitative reaction in the first part of the chambers at the time when the gasses are richest, better balanced and better fitted for active reaction. These attempts have been generally known as efforts to reduce the necessary chamber space. Among the schemes tried are the following: (1) Increase in the proportion of the nitrous oxides to the sulphur dioxide in circulation, thereby increasing the speed of the initial reaction—Systeme intense. (2) Shortening up the first chamber and

passing the gasses through cooling and drying apparatus or surface condensers before admission to succeeding chambers so as to increase the intensity of the secondary reactions—Lunge plate columns, Gilchrist pipe columns, etc. (3) Division of initial volume of gas into two or more chambers in parallel instead of in series with a reduction of the secondary chamber space. All these, and some other methods

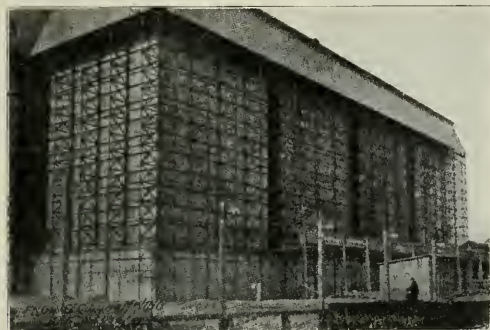


Fig. 2.—Group of High Chambers at Copper Hill, Tenn.

(Meyer tangential, Pratt process, etc.) have only been partially successful, principally, I believe, on account of the flue shape of the chambers tending constantly to pull the gas forward before sufficient time has elapsed for quantitative reaction at the proper place, with results above stated, i. e., reduced intensity of reaction, etc.

From the foregoing it seems to be reasonably clear that if the first part of the chamber system could be increased in size and the gas contents could be allowed to remain for a sufficient time free from interference by the draft pull to the exit then a quantitative reaction would take place under the best possible conditions both as to speed and completeness.

THE MOST MODERN TYPE OF CHAMBER.

The difficulty in securing the desired condition lies in the difficulty of separating the gases which still contain sulphur dioxide and are capable of further reaction from those in which the reaction is completed, but as the reaction is strongly exothermic it seemed to me that it should be possible to take advantage of the laws of convection of gases to bring about such separation. To do so would clearly necessitate increasing the length of the vertical axis of the chamber or the height in relation to all other dimensions, so as to allow relative zones of reaction and inaction therein, the incoming gas being admitted to the zone of reaction and the outgoing gas being drawn from the zone of inaction. The cubic contents of the chamber of course would have to be proportionate to the volume of gas admitted and the height proportionate to the time necessary for quantitative reaction, and the gas travel would be vertically downward, subject to convection currents, instead of horizontally forward.

Bearing these considerations in mind it becomes clear what may be the effect of increasing the length of the vertical axis of the chambers, or in other words the height in relation to all other dimensions. The gas mixture, admitted to the chamber, immediately sets up a strong exothermic reaction. If the chamber is high, convection currents will be set up and the reacting gas will immediately tend to rise and to remain at the top so long as the active reaction goes on, only the inert, non-reacting, non-heat producing, and therefore cooler gases tending to return to the bottom of the chamber, probably down the cooler chamber sides where their heat is radiated. If the relationship of the height to the area and the volume of gas admitted is correct, the reaction taking place in the chamber will be quantitative and the gas drawn from the chamber at the bottom will consist entirely of nitrous compounds and inert nitrogen with some oxygen. In other words the process will be completed in one chamber and the necessity of further chambers, which cost just as much as the first active chamber, for more and more sluggish processes or decreased efficiency in work done will be obviated and a great economy in cost of chamber space will be secured.

The accompanying diagram, Fig. 1, will best illustrate this point. Three systems of chambers are represented. No. 1 shows the actual dimensions of the new chambers as recently built by me near Pittsburg, Pa. and in Tennessee.¹ Capacity 175,000 cu. ft. (4952.5 cu. m.). No. 2 shows approximately the same capacity, 174,480 cu. ft., erected according to Dr. Theodore Meyer's tangential plan. No. 3 represents approximately the same capacity, 174,960 cu. ft., in horizontal chambers, not an unusual construction. Ad-



Fig. 3.—Complete Plant at Vandergrift, Pa.

mitting that the efficiency of this cubic capacity is the same in each case, then the approximate relation as to surface area and lead required between the three systems is as shown in the accompanying table:

COMPARISON OF SURFACE AREA AND LEAD REQUIRED.

No. 1. 19,000 sq. ft. 7 lb. lead = 66.5 short tons
(1765 sq. m. = 60,315 metric tons).

¹U. S. patent 470,189 of 1909.

No. 2. 31,412.3 sq. ft. 7 lb. lead = 110 short tons (2918.2 sq. m. = 99.77 metric tons).

No. 3. 32,004 sq. ft. 7 lb. lead = 112 short tons (2973.17 sq. m. = 101.584 metric tons).

As shown, there is a saving of approximately 40 per cent of lead required in favor of my system of high chambers, for the same cubic capacity and without reference to the increased efficiency of such chamber space.

Referring to this high chamber, System No. 1, it is true that the gas leaving the chamber will still be too moist and at too high a temperature to permit its admission at once into the Gay Lussac towers and apparatus must be provided for the drying and cooling

the chambers contain any SO_2 and the reaction taking place in the chambers is therefore quantitative.

It is too soon to state what the ultimate capacity of this form of chamber will be. There were few data available for such a radical change in construction. The one plant was supplied with fluctuating gas diluted with carbon dioxide from copper matte-smelting furnaces, which in itself was a novel undertaking. At the other plant, which was the first to be built, consisting of one chamber (175,000 cu. ft.) with Glover and Gay Lussac towers and a small cooling column, the chamber capacity was found to be entirely in excess of the burner capacity; in other words the chambers proved capable of doing more work than had been an-

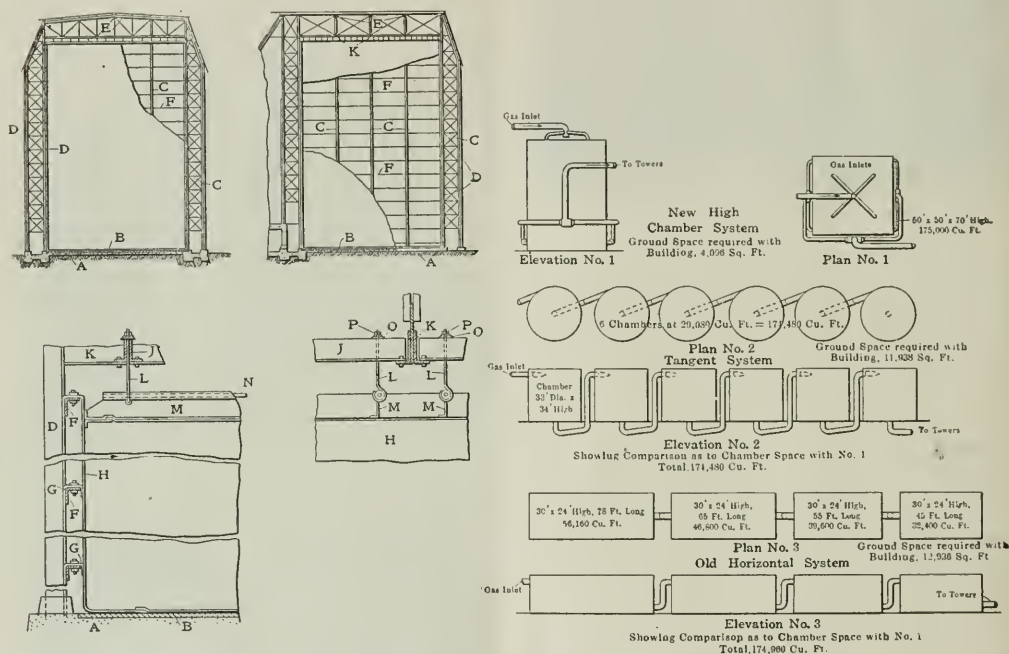


Fig. 4.—Details of Construction and Chamber Space Comparison.

of the gas. This, however, can be done with much greater efficiency and economy than by providing additional chamber space.

RECENT INSTALLATIONS.

Two sulphuric plants have recently been constructed by me, on this principle with chambers 50x50 and 70 ft. high. In both places the chambers function in identically the same way, i. e. they are hottest at the top and cool gradually to the bottom, where the difference in temperature between top and bottom, taken with side bent-thermometers, varies from 22 to 7 deg. F., according to the intensity with which the system is being driven. When the chambers are in normal condition in neither case does the gas leaving

anticipated. By forcing the burners, however, to an undue extent which could not be maintained for a great length of time, the following results have been attained, and it is confidently expected that with adequate gas supply, these results can be obtained normally and can probably be bettered. These results were obtained during the month of May, neither in hot summer nor the cold winter.

Test No. 1.—Sulphur, 25,600 lb. (11,609.6 kg.) yielding 48 tons (43,536 metric tons) of 60 deg. B. acid in 24 hours. Equal to 1 lb. of sulphur to 6.85 cu. ft. of chamber space (1 kg. S. to 0.4274 cu. m.). Average gas, 7.9 per cent. SO_2 . Average N_2O_5 in nitrous vitriol 2.2 per cent. NaNO_3 95 per cent. 720 lb.

(326.52 kg.) = 2.81 per cent on sulphur burned. Average difference between temperature at top and bottom of chamber 7 deg. F. (3.88 deg. C.). Temperature of gas entering Gay Lussac towers, 114 deg. F. (45.5 deg. C.).

Test No. 2.—Sulphur, 23,200 lb. (10,521 kg.) yielding 43.5 tons (39.45 metric tons) of 60 deg. B. H_2SO_4 in 24 hours. Equal to 1 lb. of sulphur to 7.55 cu. ft. of chamber space (1 kg. S. to 0.4709 cu. m.). Average gas 8.1 per cent SO_2 . Average N_2O_3 in nitrous vitriol = 2.19 per cent. Average NaNO_3 95 per cent, 720 lb. (326.52 kg.) = 3.1 per cent on sulphur burned. Average difference between temperature at top and bottom of chambers 8.3 deg. F. (4.61 deg.). Temperature of gas entering Gay Lussac towers 113 deg. F. (45 deg. C.).

At this plant the normal burner capacity does not exceed 16,000 lb. (7256 kg.) of sulphur in 24 hours or 1 lb. of sulphur to about 10 cu. ft. of chamber space and at this rate the plant readily takes care of the gas with a reasonably low consumption of nitrate of soda.

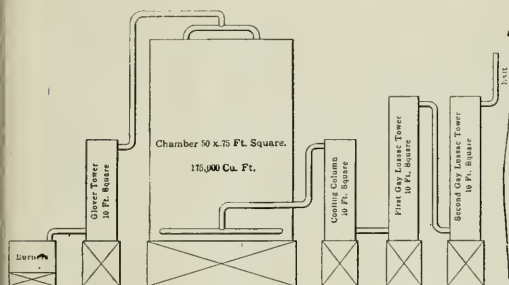


Fig. 5.—Diagram Showing Relative Proportions of a Single High Chamber Plant.

It is evident that the gas, especially when the chambers are performing high daily, enters the Gay Lussac towers at far too high a temperature, although the constant and high percentage of the N_2O_3 content, 2.2 per cent, of the nitrous vitriol, the complete absorption of the nitrous oxides in the Gay Lussac towers, the reasonable consumption of nitrate of soda, the high yield of acid and the failure to find the presence of SO_2 by the ordinary gas tests, show conclusively the complete oxidation of the SO_2 in the chamber. When adequate burner capacity and sufficient cooling apparatus between the chamber and the Gay Lussac towers are installed, the efficiency as well as the economy of this method of construction would seem to be evident. Attention might also be called to the great economy of ground space occupied by these chambers, approximately a saving of 66 per cent in favor of the high chambers for the same cubic capacity and without reference to the increased efficiency of such chamber space.² The general arrangement and relative proportions of such a plant are shown diagrammatically in Fig. 5.

CONSTRUCTION OF CHAMBERS.

The chambers are built upon a slab of reinforced concrete, *A*, Fig. 4, which may rest directly upon the ground or which may be supported upon concrete pillars in such a way as to provide a room or basement which serves for the tanks and pumping apparatus for the acid circulation and other purposes. On this slab is placed a layer about $\frac{3}{4}$ in. thick of specially prepared asphalt *B*, perfectly smooth to receive the bottom lead of the chambers.

The framework of the chamber consists of a number of steel side trusses *C* with Z-bar chords or posts *D*. These trusses or truss posts at the bottom are bolted to suitable anchorage embedded in concrete piers and at the top carry the roof trusses *E*. These side trusses are tied in place by angle-iron girts *F*; those on the inner side of the truss carry the lead sides of the chambers which are connected to them by continuous horizontal straps *G* burned to the lead sides and clamped and bolted to the angle-iron girts in such a way that the angle iron is in contact with the strap only and does not touch the side lead sheets *H*. The girts at the outside of the vertical trusses serve to attach the sheathing of the building to the lead sides of an adjoining chamber. The roof trusses *E* are connected by a series of pairs of angles forming joists *J*, which rest upon the lower chords of the trusses *K* and are bolted to them. Hook bolts *L* pass between these pairs of angle and engage in specially constructed straps burned to the top of the chamber lead *M*. These straps are continuous and are reinforced with $\frac{3}{4}$ iron rods *N*. These straps also greatly assist radiation from the chamber tops and sides. The hook bolts are supported by cast iron washers *O* resting on the pairs of angles and may be adjusted as to length by the nuts *P* threaded to the bolts and resting on the cast-iron washers. The outer chords of the truss may be flat or so shaped as to conform to the roof slope desired.

This framework, though light, is rigid and strong and the details of construction are such as to allow great facility of access for repairs or painting. At no point does the framework come into actual contact with the lead sheets forming the sides or top of the chamber.

²At the Tennessee plant, using smelter gas, a series of gas tests was made in December, 1908, under the direction of X. L. Heinz; the average results are given below. On Dec. 8 and 9 the high percentage of the burner gas precluded the possibility of there being a sufficient excess of oxygen, on account of the dilution of the gas with CO_2 as will be more fully explained in a future article. This accounts for the SO_2 present at the exit of the chamber. At the time these tests were being made the condition of the smelting furnaces was most unsatisfactory and the chamber process was by no means at its best.

	Dec. 6	Dec. 7	Dec. 8	Dec. 9
Entrance to Glover, per cent. SO_2	6.8	6.1	7.8	8.4
Exit from chamber, per cent. SO_2	none	none	0.33	0.46
Exit from cooling chamber, per cent. SO_2	none	none	none	none
Exit from Glover, per cent. SO_2	none	none	none	none
Exit from Gay Lussac, per cent. SO_2	none	none	none	none

In 1908, 23 cement plants were in operation in Canada, with a total daily capacity of 27,500 barrels, or an annual output of some 8,250,000 barrels, if all were running full time.



AN AUTOMATIC FILTERING APPARATUS.

By W. P. FITZGERALD,

Chief Chemist, J. T. Baker Chemical Co., Phillipsburg, Pa.

The cut illustrates an apparatus that is becoming very popular with a great number of chemists. The apparatus was originally intended to automatically fill the funnel while filtering but has been put to other useful applications.

The cut of the apparatus is almost self-explanatory. It consists of a well-annealed glass reservoir, with a



Sketch of Automatic Filtering Apparatus.

capacity of 300 cc., having three openings (one at the top, one at the side near the top and one at the bottom) and a long glass rod fitted with a ground stopper for closing the lower opening. The upper opening is closed by a perforated rubber stopper which is removed only to pour in the liquid to be filtered. The apparatus works the same as inverting a flask containing the liquid to be filtered over a funnel with its filter-paper, having the opening of the flask a little below the edge of the paper, but does the work much more conveniently and accurately.

When wanted for use it is set up as illustrated, with the lower opening about three-sixteenths of an inch below the edge of the paper. The glass rod is pushed

down until the ground stopper closes the opening. The rubber stopper is then removed from the side opening and the liquid to be filtered is poured in. The glass rod is now gently raised until enough liquid has entered the funnel to close the lower opening. At this point the stopper is replaced in the side opening and the glass rod raised an inch or two. The level of the liquid in the funnel starts to recede at once, exposing the lower opening, allowing air to enter at this point, with the consequent replenishing of the liquid to the funnel. After a filtration is made the precipitate may be washed in like manner with distilled water.

A great variety of work can be done by this useful little device and it is especially valuable when, as frequently happens, the chemist has not time to complete a filtration before leaving for home at night. He can put the liquid in the apparatus before leaving the laboratory and find it filtered the next morning.

It answers the purpose of a separatory funnel or to keep a constant level in an evaporating dish when taking down large quantities of solution.

All flocculent precipitates wash down the sides with ease, while a barium sulphate precipitate tends to stick to the glass, and consequently it is not used for the separation of barium sulphate.

There is no difficulty in cleaning the apparatus as all of the openings are large.

The apparatus may be procured from the laboratory of the J. T. Baker Chem. Co., Phillipsburg, N. J.

Coal Tar as a Coating for Iron Pipes.

In a paper read before the fifth annual meeting of the Illinois Gas Association, Mr. Robert B. Harper considers clean coal-tar pitch, free from water, acids or soluble mineral matter, as the most efficient type of covering for the prevention of soil and electrolytic corrosion of iron pipes. Such a pitch, he states, should be as hard as it is possible to make it without being brittle at ordinary temperatures, and should not crack when struck a hard blow. The pipes to be coated should be smooth, free from moisture, rust and loose scale or any foreign matter. Burrs or other projections of metal should be filed down before coating. The clean pipe should be left in a melted bath of pitch until the metal and dip are of the same temperature, which should be just sufficient to melt the pitch to a uniform liquid condition. The pipe, when removed, should have a smooth, uniform, black, glossy coating, 1/32 in. thick and free from lumps, bubbles or foreign matter. It may be profitable to wrap the cold coated pipe with an overlapping strip of a tough, yet flexible paper, or with cloth, and reimmerge the wrapped pipe in tar.

THE DETERMINATION OF VOLATILE COMBUSTIBLE MATTER IN COKE AND ANTHRACITE.¹

By PORTER W. SHIMER.

Consulting Chemist and Metallurgist, Easton, Pa.

While the standard method² for the determination of volatile combustible matter gives useful results on soft coals—for which class it is primarily intended—the results are far too high when applied to coke and anthracite. This is due to oxidation of carbon and, to a lesser extent, to mechanical loss. The atmosphere within the crucible is oxidizing throughout the whole seven minutes' ignition in the case of coke and for perhaps the greater part of the time in the case of anthracite. In the latter case, owing to the decrepitation of this coal when suddenly heated, the mechanical loss may be serious. A number of investigators, among them Meade and Attix³, have proposed making this determination in an atmosphere of nitrogen or hydrogen. This, of course, necessitates the use of special apparatus and requires a good deal of time and attention. The results are trustworthy.

For many years, until recently, the writer determined volatile matter on a five-gram sample of coke and anthracite, using a 25 cc. crucible. Before making the ignition a piece of wet asbestos paper was placed over the mouth of the crucible and the closely fitting cover was carefully and firmly pressed down upon it. This made a rather tight joint and the oxidation and mechanical loss were very much lowered. The larger weight of the sample (five grams as against one gram) also lessened the percentage of loss by oxidation.

By a slight modification, however, the standard method may be successfully used. Instead of using a crucible with its cover, the writer now uses two platinum crucibles, without covers, of about 15 cc. capacity each. These are of such a size that, when the smaller one is placed inside the larger one, there will remain an open space at the bottom of about one-quarter inch. The crucibles should be well formed and undented so as to make a close joint, the inner one taking the place of a cover. A porcelain crucible may be used in place of the inner one, if of proper size and cylindrical in shape, but one of platinum is to be preferred.

The method, in brief, is as follows: Ignite the combined crucibles, cool and weigh. Remove the upper one and place it alongside of the other on the balance pan. Weigh into the lower crucible one gram of coke or anthracite. Press the smaller crucible securely down into the lower one and heat for three and a half minutes over the Bunsen and immediately follow this with three and a half minutes over the blast lamp. Simple ignition of seven minutes over the Bunsen, as in the standard method for soft coal, is not enough to drive off all the volatile matter from coke and anthracite. By this double crucible arrangement the interior

air space is cut down to a minimum and the joint between the two crucibles is of such a character that very little, if any, air can enter during the ignition. Two more things may be done to minimize still further any possible loss by oxidation. Ten drops of absolute alcohol may be placed on the coke and this may be burned off—in the process expelling the air—by gently and carefully warming the crucibles before beginning the seven minutes' ignition. In most cases, however, this addition of alcohol causes no material difference in the results. A useful precaution to minimize mechanical loss, especially in the case of anthracite, is to work into the joint between the two crucibles a very little stiff starch or flour paste. At the beginning of the ignition this carbonizes instantly and serves to retain the decrepitated particles thrown off in the early part of the ignition. The paste is completely burned away some time before the end of the operation.

In certain cases the crucible containing the coke is more or less attacked, and it is well, therefore, to use a small boat easily made of thin platinum foil, fitting closely into the larger crucible and high enough to contain the sample. A few of the results obtained in this investigation will suffice to show the difference between the two methods of ignition.

A one-gram sample of coke lost in seven minutes' ignition, as in the standard method, with crucible cover, 2.96 per cent volatile matter. The same sample, when given another seven minutes' ignition in the same way, lost 1.97 per cent additional.

Using the same Bunsen flame, a one-gram sample of the same coke, ignited for seven minutes in the double crucible, lost 1.20 per cent and, on giving it an additional seven minutes, the loss was only 0.12 per cent.

To show that all the volatile matter is not driven off by the Bunsen flame alone, the following results, among many similar ones, are given. A one-gram sample of another coke yielded 1.51 per cent volatile matter by seven minutes' ignition over the Bunsen flame in the double crucible. The sample was again heated for three and one-half minutes over the blast lamp and sustained a further loss of 0.73 per cent volatile matter. On igniting again for three and one-half minutes over the blast lamp there was no further loss.

It is not necessary to insist on the importance of a fairly accurate determination of volatile matter, for it is not only of value in itself but is essential to the correct determination of fixed carbon.

Electrolytic copper wire is being made by electrolytic disposition on revolving mandrels scored with V-shaped spiral scratches. These mandrels are revolved in the electrolyte until the desired thickness of copper is deposited, when the metal is unwound in long strips readily finished into homogeneous wire of great tensile strength. According to the inventor, Mr. Sherard Cowper-Coles of England, these strips may be made four miles in length.

¹Read before the Lehigh Valley Section of the American Chemical Society, May 8, 1909.

²Jour. Amer. Chem. Soc., 21, 1116.

³Ibid 21, 1137.

THE EXAMINATION OF BITUMINOUS MATERIALS FOR ROAD CONSTRUCTION.*

By CLIFFORD RICHARDSON and C. N. FOREST.

New York Testing Laboratories, 50 Church St., New York.

Specific Gravity.—The specific gravity of light oils is determined with a pycnometer or a Westphal balance at 25 deg. C. Heavy substances, too viscous for test by the above instruments, are examined by the Kirschbraun method:

Take a test tube about $\frac{1}{2}$ in. in diameter and cut it off to give a $\frac{1}{4}$ to $\frac{1}{2}$ -in. tube. Flare it out to carry a fine wire. Put about 10 grams of the oil or asphalt into it, and suspend it in an oven to remove air bubbles and drive off the water. Cool and weigh accurately in air and immerse in distilled water at 25 deg. C. to a fixed mark on the wire and weigh. Previous to filling the tube with the sample, determine its weight carefully in air and in water at 25 deg. C., immersed to the fixed mark. These weighings give the weights of the tube alone, in air and in water, and the combined weights of the tube and the sample in air and water. The gravity is calculated in this way, representing weight of tube in air by a , weight of tube and sample in air by b , weight of tube in water by c , and weight of tube and sample in water, d .

$$\text{Sp. Gr.} = \frac{\text{Wt. in air of sample}}{\text{Loss of wt. in water}}$$

in this case becomes

$$\frac{b - a}{(b - a) - (c - d)} \quad (1)$$

When the gravity of the sample is less than unity, the second expression in the denominator is a negative ($d - c$) quantity and is added to the original weight of the sample ($b - a$), inasmuch as the buoyancy of the sample will overcome its own weight, and, to a certain extent, will also reduce the weight of the tube in the water, making c greater than d .

The formula in this case may be also expressed so:

$$\frac{b - a}{(b - a) - (c - d)} \quad (2)$$

When the gravity of the sample is greater than unity, d will be greater than c and the first formula applies without confusion. As an example, take a blown oil, the gravity of which was determined in our laboratory according to this method: $a = 4.7870$; $b = 16.7900$; $c = 2.8565$, and $d = 2.6425$; by formula (2)

$$\begin{aligned} \text{Sp. Gr.} &= \frac{16.7900 - 4.7870}{(16.7900 - 4.7870) + (2.8565 - 2.6425)} \\ &= \frac{12.0030}{12.2170} = .9817 \end{aligned}$$

This may seem a bit complicated at first, but it will

be noticed that the factors a and c are constants, which can be used for the same tube without change, and the calculation becomes very simple after a few trials.

The advantages of the method are in doing away with the inconveniences of handling a large amount of oil, and the ease with which air bubbles can be removed. Of course, it can be used only with oils which are viscous enough to be retained in the tube when under water.

Flash Test.—The flash point is determined in a New York State closed oil tester. The water bath is, of course, removed and the oil heated directly with a flame of a size to raise the temperature at the rate of 20 deg. F. per minute, and a small flame from a capillary glass or metal tube is used for flashing. The flame should be applied at 5 deg. intervals. The determination should be repeated for such oils as flash at unexpected temperatures. The water must be removed from the oil or flux before putting it in the tester cup, either by heat or by the centrifugal.

Bitumen Soluble in Carbon Disulphide, or Total Bitumen.—One gram of the dry material is weighed out and introduced into a 200-cc. Erlenmeyer flask of Jena glass and covered with about 100 cc. of carbon disulphide. It is then set aside for at least five hours, or over night, at the temperature of the laboratory. In the meantime, a Gooch crucible is prepared with an asbestos felt and weighed. This Gooch crucible is of special form, with a large filtering surface. It holds 30 cc., is 4.4 cm. wide at the top tapering to 3.6 cm. at the bottom and 2.6 cm. deep. This is much better for percolation work than the usual narrow form of Gooch. The felt is made by heating up long-fiber Italian asbestos in a mortar, and suspending the finer particles in water and quickly pouring off from the coarse particles. Too much of the latter should not be removed, or the felt will be too dense. The decentered asbestos and water are shaken up, and what is found to be a proper amount poured into the crucible, which has, in the meantime, been attached to a vacuum filtering flask by the proper glass and rubber connections. As soon as the asbestos has somewhat settled, the vacuum pump is started and the felt firmly drawn on the bottom of the crucible. It is then dried, ignited and weighed.

After standing a proper time, the disulphide is decanted very carefully upon the filter, which is supported in the neck of a wide-mouthed flask and allowed to run through without suction. The flask, after being tipped to pour the first portion, is not again placed erect, in order to avoid stirring up any insoluble material, but is held at an angle on any suitable base, such as a clay chimney. After all the disulphide has been decanted, more is added and the insoluble matter shaken up with it. This is allowed to settle, and decanted as before, the insoluble matter being finally brought on the filter and washed with the solvent until clean. The excess of disulphide is allowed to evaporate from the Gooch crucible at the temperature of

*Read at the recent meeting of the American Society for Testing Materials.

the room. It is then dried for a short time at 100 deg. C. and weighed. The loss of weight is the percentage of bitumen soluble in carbon disulphide.

In the meantime, the filtrate, transferred to a platinum dish, is placed in a good draught and lighted. When all the disulphide has burned, the bitumen remaining in the dish is burned off over a lamp and the mineral residue, which escaped the filter, is weighed. The weight is added to that of the Gooch crucible or subtracted from the percentage of bitumen found without its consideration, as a correction. Care must be used in this method of procedure that the solvent does not creep over the sides of the crucible and that the outside is free from bitumen before weighing. In order to avoid this, the crucible is preferably supported in the neck of a flask with three constrictions, the neck extending above the top of the crucible and the latter being covered with a watch glass.

Naphtha Soluble Bitumen.—One gram of the substance is weighed into a 200-cc. Erlenmeyer flask, covered with naphtha, and allowed to stand, as in estimating total bitumen; in fact, the entire process is the same, with the exception that one or two precautions must be observed. It is well not to attempt to break up any lumps with a stirring rod, as the substance, especially the softer asphalts, may then adhere to the rod or flask and be difficult to detach. It may also be necessary to treat the substance with several portions of the solvent. No heat is applied at any time in the process, and the filtration is made without suction.

Character of Naphtha Soluble Bitumen.—The filtrate containing the naphtha soluble bitumen is evaporated spontaneously in a crystallizing dish until the naphtha is expelled. At 77 deg. F. the residue in the dish is tested with the fingers to ascertain whether it is merely oily or of a sticky and adhesive character.

Residual Coke or Fixed Carbon.—This determination should be made according to the method described for coal in the "Journal" of the American Chemical Society, Vol. 21, page 1116.

Place 1 gram of pure bitumen in a platinum crucible weighing 20 or 30 grams and having a tightly fitting cover. Heat over the full flame of a Bunsen burner for seven minutes. The crucible should be supported on a platinum triangle with the bottom 6 to 8 cm. above the top of the burner. The flame should be fully 20 cm. high when burning free, and the determination should be made in a place free from draughts. The upper surface of the cover should burn clear, but the under surface should remain covered with carbon.

The residue minus the small impurity of ash in the pure bitumen is the fixed carbon, which should be calculated to 100 per cent with the volatile hydrocarbons, excluding the inorganic matter.

Paraffine Scale.—The distillation method is employed for this purpose.

One hundred grams of the oil is distilled rapidly in a 6-oz. retort to dry coke.

Five grams of the well-mixed distillate is treated in a 2-oz. flask with 25 cc. Squibb's ether; after mixing

together thoroughly, 25 cc. Squibb's absolute alcohol is added, and the flask packed closely in a freezing mixture of finely crushed ice and salt for at least 30 minutes. Filter off the precipitate quickly by means of a suction pump, using a No. 575 C. S. & S. 9-cm. hardened filter, cooled by the above freezing mixture in a suitable apparatus.

Rinse and wash the precipitate with 1 to 1 Squibb's alcohol and ether mixture, cooled to 0 deg. F., until free from oil; 50 cc. of the wash solution is usually sufficient. When sucked dry, remove the paper, transfer the waxy precipitate to a small glass crystallizing dish. Dry on a steam bath and determine the weight of paraffine scale remaining in the dish.

$$\frac{\text{Wt. of Paraffine}}{\text{Distillate taken}} \times \text{per cent original distillate} \\ = \text{per cent paraffine scale.}$$

Viscosity.—The viscosity of bituminous road material is determined in the Engler viscosimeter at any temperature desired. The full quantity, 250 cc., is placed in the apparatus and raised to the temperature at which it is desired to make the test; 100 cc. is then permitted to flow into a graduated flask of the above capacity, and the time of flow in seconds noted. The result may be expressed either in seconds or by ratio compared with the time of flow of a similar quantity of water at 77 deg. F.

Road binders should be too viscous for testing in the Engler apparatus at temperatures below 250 to 350 deg. F., and to determine the consistency of such materials at normal or slightly elevated temperatures, the New York Testing Laboratory float apparatus is employed.

Cementing Value.—Petroleum oils have very feeble, if any, cementing value. Materials requiring a high temperature to flow freely will not adhere to cold road metal. To determine these properties the material under examination is heated to the temperature at which it is used in practical work, and a portion is then flowed over the surface of a slab of marble or glass, 4 x 5 x 1 in. thick. After standing 24 hours at 77 deg. F., the film upon the stone must be decidedly sticky when tested with the fingers, and must adhere to the stone so that it cannot be pulled off.

Volatile Substances.—For this test 100 grams of the material is placed in a 6-oz. tubulated glass retort, with the bulb of an accurate thermometer immersed in the same. Heat is now applied so that the temperature rises at the rate of 10 deg. per minute to 700 deg. F. The distillate, if any, is regarded as the amount of volatile substances in the material. The residue is examined by the New York Testing Laboratory float for consistency, and compared with the results obtained upon the original material by this test.

During the first six months of 1909 the imports of iron ore into Belgium amounted to 2,057,267 tons.

METALLURGY.

INFLUENCE OF CHEMICAL COMPOUNDS ON THE PROPERTIES OF IRON.*

By A. H. HIORNS.

Much work has been done of late years on the influence of certain elements on the properties of cast iron, and several workers have studied the formation of chemical compounds of iron with those elements which are usually associated with iron in commercial varieties, with the result of establishing the existence of several well defined compounds having definite physical properties.

It is now well recognized that compounds are formed in alloys at definite temperatures. The result is that on cooling such an alloy the compound is decomposed into its constituents. In other cases the reverse condition takes place. It naturally follows that the properties of such an alloy must vary with the conditions of such elements, according as they exist in chemical combination or in the free state.

Very closely associated with the subject of chemical combination is that of solution, both liquid and solid. A chemical compound in a metal is generally a hard and brittle substance; it is therefore reasonable to assume that it tends to impart those properties to the metal in which it is involved, in proportion to the quantity present, but the manner in which the compound exists in the alloy, whether segregated in the free state or in solution, or in a finely divided state, as in eutectic mixtures, modifies its influence on the whole mass.

As an illustration we may take the case of the carbide of iron, Fe_3C . This carbide exists in iron in three ways, viz., in solid solution, termed martensite, in segregated patches, as cementite, and in fine striations as in pearlite. In solid solution as in hardened steel and white cast iron it exerts the maximum hardening effect, and in fine striations the minimum hardening effect. Also the maximum hardness is associated with the maximum brittleness.

The chemical compounds of one metal with another do not in general follow the law of valency, so that they are of the type known as molecular, but the above law is obeyed in the compounds of non-metals with iron. It may also be stated that when the law of valency is strictly followed, the combinations are of a stable character, and when it is not the compounds are easily decomposed, and the properties of the alloys will vary with the strength of the chemical combinations present. Also in the case of weak combinations the properties will vary much less from the properties of the components than in the case of strong combina-

tions. The usual combinations of elements with iron in cast iron and steel are of the strong character, hence they are capable of profoundly modifying their properties.

The solid solutions of elements in compounds of iron, while fairly strong, are much less so than the chemical compounds, and the properties of such solutions do not differ very markedly from the mean of the properties of the bodies dissolved in each other. In a solution the components are completely merged, but in indefinite and varying proportions, so that the components cannot be distinguished by the microscope or any other means. Seeing that a solid solution may contain varying quantities, it may often happen that the quantities present may be in atomic proportions, yet this will not prove it to be a chemical compound.

ELEMENTS IN CAST IRON.

There is another state in which elements may exist in iron, analogous to a solid solution. The two elements are isomorphous, they crystallize in the same shape; proportions of each may form one homogeneous crystal, the molecules of each substance completely identifying themselves with the molecules of the other. Such isomorphous crystals are also called "mixed" crystals. As an illustration we may take iron and manganese. The molecules of each unite to form one homogeneous crystal. These elements therefore constitute a solid solution, but two elements of different crystalline forms may merge and form a homogeneous solid, and while this would be a solid solution it would not be a true isomorphous mixture. Solid solution may consist of a chemical compound dissolved in a metal, as in the case of the carbide of iron Fe_3C , dissolved in iron, which is the condition in white cast iron and hardened steel.

It may be granted that an isomorphous mixture of a solid solution has properties differing from the properties of the components in proportion to the relative quantities present, so that the existence of manganese in iron, or Fe_3C in iron will modify the properties of iron in proportion to their amounts. Further, a dissolved body may only be capable of existing in solid solution under certain conditions as to temperature, etc. For example if the solution of Fe_3C in iron is cooled down below 1,000 degrees C. it will more or less fall completely out of solution if sufficient time be allowed for the separation. It may also be granted that a solvent generally is capable of taking up a limited quantity of another body, and if an excess be added beyond the saturation point, such excess will not be dissolved, or if dissolved will readily separate out again.

With regard to this paper, the usual elements found

*Paper read before the British Foundrymen's Association, August 3d-5th, 1909.

in cast iron only will be considered. These are carbon, silicon, phosphorus, sulphur and manganese of which carbon, silicon, phosphorus and sulphur form chemical compounds with iron, but not manganese. The latter, however, forms compounds with carbon, sulphur, silicon and phosphorus.

Silicon forms compounds with sulphur but not with carbon, at the temperature at which cast iron is produced.

Sulphur unites with carbon to form a volatile compound. As therefore several compounds can be formed in cast iron it is reasonable to suppose that they play an important part in controlling the properties of the various grades of cast iron, and in the case of carbon the most important of all influences in determining those properties. If therefore we wish to arrive at a real notion of the nature and properties of commercial cast iron, a close study of the chemical compounds present must be pursued.

CHEMICAL COMPOUNDS AND SOUND CASTINGS.

That the casting temperature has an influence on the formation of blowholes is generally recognized, but this is not the only and in many cases the chief cause. During the casting operation gases are absorbed. A partial decomposition of the moisture of the atmosphere always occurs, and the dissociated hydrogen combines with the flowing metal. Often carbonic oxide is formed by the union of carbon of the mold with the oxygen of any oxide in the metal, but this is only partially absorbed, most of it escaping as gas, and the rest is trapped in the metal as blowholes.

Iron does not form any strong combination with gases which are dissociated as soon as the temperature falls sufficiently to permit of their evolution. As long as the surface of the metal is liquid the gases will freely escape, but as soon as the crust of the metal is sufficiently thick to resist the pressure of the ascending gases they will be retained in the metal, but as the whole process of evolution depends on the space available for the gases within the metal or on their passing through the metal the freezing of the upper part prevents any escape of gas except by the shrinkage and the formation of a pipe.

The three elements which have a most important influence in preventing or modifying the blowholes are silicon, manganese and aluminium, all of which tend to increase the capacity of iron for excluding gases. Now as aluminium is not usually employed in cast iron it is only necessary to consider the two others, although they are inferior to aluminium in the prevention of blowholes. The more the metal cools the stronger is the tendency of gases to escape, but this tendency may be counteracted by the presence of silicon, or manganese. Conversely, in the absence of silicon or manganese, the gases begin to escape at a higher temperature and are evolved during the cooling so that blowholes result. When the whole of the metal is solid, the gases can no longer form and are therefore kept in solution. The higher the percentage of silicon and manganese the greater will be the tendency to keep

the gases in solution till a temperature is reached when the whole metal is solid.

PHOSPHORUS, SULPHUR AND SILICON.

If the metal is cast at an abnormally high temperature, it will afford facilities for the evolution of gases and the formation of blowholes, since the interior will remain liquid a long time after the surface has solidified. The effect of sulphur and phosphorus is to lower the freezing point of the iron and keep the interior metal longer in the liquid state, thus causing facilities for formation of gases, and therefore formation of blowholes. Whereas silicon causes iron to pass very rapidly from the liquid to the solid condition and thus in a great measure prevents the evolution of occluded gases.

Brinell found that for steel, under conditions that are normal at Fagersta, Sweden, if the sum of the percentage of manganese plus 5.2 times the percentage of silicon is as great as 2.05 then the steel is free from blowholes. If the sum is reduced to 0.28 the blowholes are deep seated. If the sum is 1.66 there is just a small quantity of hardly visible blowholes. If between these extremes the blowholes are near the surface. These numbers must be varied with the casting temperature and size of the casting, being less for a small casting. He also found that the effect of 0.0184 per cent of aluminium was equivalent to the above sum of 1.66.

It may be added that a too high or a too low casting temperature causes the formation of many blowholes. It is thought that the reason why excessively high temperature causes external blowholes is, that it causes the carbon of the molten metal to react on the oxide of iron on the surface of the casting with the formation of carbonic oxide gas.

Both gray and white cast iron evolve gas copiously on setting but the white iron is more liable to blowholes than the gray iron. This is partly due to the fact that white iron passes through a pasty stage in solidifying, while gray iron passes quickly from the liquid to the solid state.

CAUSE OF BLOWHOLES.

Three sources of gas bubbles have been suggested. First, the mechanical retention of air drawn into the metal while pouring. Second, the formation of carbonic oxide gas by chemical reaction. Third, the gasification of substances which have existed in a non-gaseous state (solution, chemical union), and which had earlier been formed by reaction or acquired from the atmosphere or furnace gases. Blowholes are probably due chiefly to hydrogen, nitrogen and carbonic oxide. The last may be formed by superficial action of the carbon on the oxygen of the air, as it is much larger in the early than in the later escaping mold gases.

The presence of manganese and silicon in the iron it has been stated greatly assist in the the prevention of blowholes. They appear to increase the solvent power of iron for gases, but they may also prevent the formation of carbonic oxide by being preferentially

oxidized. In their absence the solvent power of iron diminishes and a greater number of blowholes result. The shape of blowholes is more regular when deep seated than when near the surface of a casting.

Martens found with the microscope three sets of markings and intrusions in blowholes. Stripes, furrows on foldings, caused by compression due to contraction of the neighboring metal. Intrusions caused by the entrance of gas from the surrounding metal after the walls of the surrounding blowholes have become pasty. Intrusions of metal due to change of volume in the surrounding metal by solidification of different components of the mass at different periods. During solidification the conditions which determine whether gas shall escape or not depends on the solvent power of the metal and on the existing pressure.

CHEMICAL COMPOUNDS AND THE CHILL.

In the first place it may be stated that chilled iron is white iron, and therefore depends on the amount of combined carbon, which is also influenced by the temperature of casting. If an increase of combined carbon does not give a greater depth of true chill, the iron at the back of the chill contains more combined carbon, so that the influence of combined carbons imparted to a considerable amount of the iron.

Silicon when present in iron forms a chemical compound, which according to Carnot and Goutal has a formula Fe_2Si , and this in cast iron is dissolved in the iron forming a solid solution, which is harder and more brittle than the iron alone. Now as this silicon is locked up in the iron, its influence on the condition of the carbon, whether combined or uncombined, is very limited. The author took a sample of cast iron containing 1 per cent silicon and free from other elements other than iron and carbon, and quenched it in water from 1100 degrees C. The whole of the combined carbon was practically in the combined form.

It is now generally recognized that the carbon, which is in solution in molten iron, remains in that state if it rapidly cooled. Adamson (Journal of the Iron and Steel Institute, 1906) mentioned a sample of silicon steel with 0.8 per cent combined carbon and no graphite. Silicide of iron also lowers the saturation point of iron and carbon but it by no means follows that the cast irons with high silicon are the lowest in carbon or contain the least amount of combined carbon. In fact the separation of carbon from iron is chiefly a function of time and temperature.

PHOSPHORUS.

Phosphorus is present in cast iron as a phosphide, probably Fe_3P , which is readily fusible, fairly hard and brittle. Unlike the silicide, phosphide of iron is not dissolved in the crystals of iron but exists in the portion which solidifies last and therefore is a constituent of the eutectic mixture. It therefore does not exert any great influence on the carbon, either to keep it in the combined form or to cause it to separate out as graphite. One effect of the phosphide is to lower the percentage of total carbon. Phosphorus in consequence of its influence in reducing the total carbon and

lowering the freezing point of iron is inimical in iron for chilling, since it reduces the depth of true chill. Moreover, phosphide of iron, being a brittle body, tends to impart that property to the iron.

SULPHUR AND MANGANESE.

Sulphur with iron forms sulphide of iron, which is a brittle substance, and while it tends to keep the carbon in the combined form and thus to promote chilling, it also tends to promote brittleness. Sulphide of iron is a comparatively fusible body and lowers the freezing point of iron, which therefore is opposed to chilling. For these reasons the amount of both phosphorus and sulphur should be low in iron for chill castings, which while they must be hard, should at the same time not be brittle, and both sulphides and phosphides induce brittleness in cast iron.

Manganese in moderate quantity is an advantage for chilling, inasmuch as it promotes the retention of combined carbon. It forms with carbon a carbide of manganese, and consequently increases the depth of chill. Up to 1 per cent it does not materially interfere with transverse and deflection tests. In the presence of sulphur manganese sulphide is formed which has no effect on combined carbon, so that in this case manganese carbide promotes brittleness. For a good chilling iron and combined carbon should be about 0.8 per cent, the graphite about 2.4, silicon and manganese about 1 per cent each, phosphorus about 0.4 per cent and sulphur about 0.04 per cent.

CHEMICAL COMPOUNDS AND SEGREGATION.

Segregation is a term applied to the more fusible parts of alloys and impure metals which are the last to solidify, and are driven into certain local centers by this part which freezes first. Segregations are generally found near the upper part of the center of a casting, and are more pronounced in large masses. Cast iron is a complex alloy containing carbides, silicides, phosphides and sulphides, etc., contained in metallic iron. These different compounds vary in their freezing points, some remaining liquid much longer than others, and all have a lower freezing point than the metallic iron.

Consequently those having the lowest freezing points will tend to segregate from the iron and collect in the hottest parts of the castings, which will naturally be near the center, as this is the last portion to solidify. But it is not the extreme top of the casting which contains the most of the segregated compounds, as this is not the last to solidify, other things being equal, the more rapidly the cooling the less will be segregation, and as the rapidity of cooling depends largely upon the size of the castings, it follows that small castings are little liable to segregation. The proportion in which the segregating bodies are present will largely influence the result. The higher the proportion of impurities in the casting the greater will be the amount of segregation.

CRYSTALLIZATION.

Mr. Stead has pointed out that segregation is closely connected with the size of the primary crystals of iron

which solidify first, leaving a liquid mass which contained the greater part of the impurities. Now quick cooling, or agitation of the mass on slow cooling, produces small primary crystals, and in iron the crystals are of the cubic system. When the crystals form rapidly they are so close together that very little of the segregate becomes entangled. Iron crystallizes in "fir-tree" systems, which send out branches at right angles, and each of these sends out branches at right angles to itself and parallel to the primary system. The liquid portion of the metal becomes entangled in these branches. When the crystallization is rapid the small crystals are so crowded together that there is no room for the branches to form and extend, so that very little of the segregate is entangled. This is the condition of the top portion of a casting.

The next set of crystals to form from the still liquid and hotter portion are larger because of the longer time they have to grow. These can throw out branches in all directions like the boughs of a tree in a thick jungle, and therefore entangle a lot of the more fusible and segregated mass. The primary crystals are not pure iron, but iron saturated probably with dissolved carbide. The bodies in cast iron most likely to segregate are the carbides, phosphides and sulphides of iron, being more fusible and of lower density than the alloys of iron and manganese.

The segregation of manganese carbide and sulphide is favored when the percentage of manganese present is in large excess of the percentage of phosphorus and sulphur. It is often found that the segregation of others. When there is an appreciable segregation of manganese, sulphur is generally present, and the segregate is therefore sulphide of manganese. The presence of the metals chromium and tungsten favors segregation, while the presence of nickel tends to prevent it and to make the casting more uniform.

CHEMICAL COMPOUNDS AND SHRINKAGE.

The contraction of cast iron on cooling varies with the proportions of the castings and the nature of the iron employed. When the constituents and the rate of cooling are such as to favor the production of combined carbon the shrinkage is greater than when the opposite condition prevails. Therefore white iron contracts more than gray iron on cooling.

Now the formation of a chemical compound often is accompanied by contraction, and a chemical compound in solution in a metal generally has the effect of closing up the grain when the compound does not exceed a certain amount, as for example, phosphorus in copper. Hence the presence of carbide of iron Fe_3C in solution in iron causes contraction of the whole mass, hence the greater shrinkage of white iron.

CARBON, MANGANESE AND SULPHUR.

Manganese has also the power of uniting with carbon to form a carbide of manganese, which dissolves in iron, and which possesses the same general tendency as carbide of iron to close up the grain and therefore causes contraction. But if sulphur is present, the manganese may unite with it to form sulphide of man-

ganese, which segregates in different parts of the casting. In this case the manganese, although in chemical combination, has no influence on the condition of the carbon, so that the carbon might exist in the free form as graphite, in which case the contraction is due to the iron and elements other than manganese and sulphur. Now while manganese carbide produces white iron with consequent much shrinkage, manganese may, as stated above, be present in quantity and produce neither chilling nor shrinkage, the iron behaving as though it were absent.

PHOSPHORUS AND SHRINKAGE.

Phosphorus is said to lessen the shrinkage of cast iron, but it is difficult to see how this can be the case since phosphide of iron, in the proportions usually present in cast iron, is positively stated by Stead to have no influence on the carbon, neither in causing combined carbon to be retained nor graphite to be set free.

If then the condition of the carbon in iron is the determining factor as regards shrinkage, it is evident that phosphorus can have no influence on the shrinkage. But phosphide of iron is in solution in iron at high temperatures, and if the iron is rapidly cooled it remains in solution. If, therefore, the effect of a chemical compound in solution is to close up the grain and cause contraction, phosphorus in that case promotes shrinkage. But with ordinary grades of iron the phosphide of iron is thrown out of solution and exists as a free phosphide. In that case it probably has no influence on the contraction, except mechanically in enlarging the eutectic mixture, and thus tending to neutralize the contracting effects of the carbide.

SULPHUR AND MANGANESE.

The effect of sulphur on cast iron depends to a great extent on the presence or absence of manganese. In the absence of manganese it unites with iron to form sulphide of iron, which is uniformly distributed through the mass when the amount of sulphur is under .08 per cent. According to Levy the first freezing point of iron containing 1 per cent sulphur is 1187 degrees C. and with 4.3 per cent carbon the eutectic mixture freezes at 118 degrees C. due to the iron sulphide forming a constituent of the eutectic. The iron sulphide seems to cement the otherwise discontinuous pearlite.

With low sulphur, which is the case in all iron castings, the pearlite and sulphide tend to coalesce with rounded mass. By the interposing of sulphide the pearlite is prevented from massing together, which is considered by Levy to be a preliminary to its decomposition into iron and graphite. He also suggests that the pressure of the iron sulphide prevents the expansion which accompanies the formation of iron and graphite from the decomposition of cementite. If, therefore, sulphide of iron is able to mechanically prevent the formation of graphite the iron must be white, because the carbide is kept in solution in the iron, and as combined carbon increases the shrinkage, sulphur in iron in the absence of manganese promotes contraction during cooling.

ANALYSIS OF COMMERCIAL CYANIDE.

In a paper on "Methods for Assaying in Cyanide Plants," Mr. W. H. Seamon, of Chihuahua, Mexico, gives the following method for the analysis of commercial cyanide:

Dissolve 20 grams of the substance in 150 cc. of water and filter off from any insoluble residue, through an ashless filter, catching the filtrate in a graduated 250 cc. flask. Wash carefully. The filter is ignited and weighed and the percentage of insoluble matter, which is SiO_2 , Al_2O_3 , Fe_2O_3 , calculated.

Determination of Carbonic Acid.—Calcium nitrate is added to the flask and after shaking, the flask is filled up to the mark with water, shaken again and allowed to stand for one hour. It is then filtered, the residue on the filter being CaCO_3 , proportional to the carbonic acid in the cyanide; it is washed, ignited and weighed as CaO ; the weight of CaO multiplied by 0.786 gives the weight of CO_2 in the 20 grams of cyanide taken.

Determination of Oil.—The filters from the CaCO_3 is diluted to 500 cc. of which 100 cc. is taken for the Oil determination. To this add a solution of magnesium nitrate and allow to settle for an hour; then filter off the precipitate of magnesium hydroxide, ignite in an annealing cup and weigh as MgO . This weight multiplied by 0.85 gives the weight of hydroxide in four grams of the cyanide, from which calculate the percentage.

Determination of Cyanogen.—Take 50 c.c. of the 500 cc. and add 5 cc. of strong ammonia and 5 cc. of the potassium iodide indicator; then run in the standard solution of silver nitrate. The CN factor is obtained from the Cl factor by multiplying it by 0.7324, and it will be about 1 cc.=.0036 CN, when 1 cc.=.0005 Cl.

Determination of Cyanate.—Take 50 cc. of the solution and add an excess of a strong solution of silver nitrate which will precipitate all of the cyanogen, cyanate and chloride combined with the silver; shake well; filter and wash with ice cold water. After washing place a clean flask beneath the funnel and pour over the filter 10 cc. of standard nitric acid solution, made by mixing 100 cc. of nitric acid with 900 cc. of distilled water. The cyanate will act upon the nitric acid. The excess of nitric acid is determined by titration with a standard solution of caustic soda. Each molecule of HNO_3 corresponds to one molecule of CNO . Having determined the number of cc. of the normal nitric acid that have been consumed by the silver cyanate, as well as the weight of HNO_3 in 1 cc. of the standard solution, the weight of CNO is found by multiplying cc. of HNO_3 by weight of HNO_3 , multiplied by 0.6666, from which weight the percentage of CNO may be determined.

Determination of the Chlorine.—Weigh out one gram of the powdered salt into a small porcelain crucible and heat it, gradually adding a mixture of five

parts of Na_2CO_3 and one part of KNO_3 until all of the cyanogen is decomposed. Cool and dissolve the mass in water, acidify with nitric acid and filter to clear the solution. The chlorine can then be determined by titrating with a standard solution of silver nitrate; or it may be precipitated with silver nitrate and determined in the gravimetric way.

Determination of Potassium and Soda.—Decompose in a platinum dish 0.25 grams of the powdered salt, with dilute hydrochloric acid, being careful to perform the operation under a hood with strong draft to avoid injury from the poisonous fumes; evaporate to dryness and ignite to drive off all salts of ammonia, cool and weigh as $\text{NaCl} + \text{KCl}$. Then determine the potassium with platonic chloride and the sodium by difference.

Remarks on Cyanide.—Pure potassium cyanide contains 40 per cent of cyanogen and in the trade corresponds to 100% cyanide. Ninety-eight per cent cyanide contains only 39.2% cyanogen and 125% cyanide contains 50% cyanogen. It has been found that potassium cyanide carrying sodium cyanide is more efficient than the pure article, weight for weight, owing to the larger percentage of cyanogen. This is economy—in the reduction in freights and also for the additional reason that the combined cyanide can be made and sold more cheaply than the pure potassium cyanide.

New Electric Resistance Laboratory Furnace.

A new form of electric resistance laboratory furnace recently invented by Prof. Holborn of Berlin, permits of temperatures up to $1,500^\circ \text{C}$. being attained with ease by use of the ordinary 110-volt electric supply. The furnaces are made in two forms, the first being adapted for heating crucibles and the second for heating tubes 44 centimeters in length. In both forms of furnace the electric current is conducted through a resistance coil of platinum or nickel wire wound around a thin porcelain tube or cylinder. The crucible, or substance to be heated, is placed within this latter and the space between the outer side of the coil and the containing vessel is packed with asbestos or powdered quartz. Using nickel, the temperature of the furnace cannot be raised above $1,000^\circ \text{C}$. without damage to the coil. But with platinum it is possible to attain a temperature of $1,500^\circ \text{C}$. with a current of 14 amperes and 110 volts.

Electrolytic brass has been experimentally made by Mr. S. Field according to a paper recently read before the Faraday Society. Electrolysis of a solution of the double cyanides of copper and of zinc causes a deposition of these metals on the anode. According to the chemical equations of the reactions the same current will deposit about twice as much copper as zinc, which is a good proposition for brass. Constant stirring of the solution is necessary. The possibilities of making alloys by electro deposition are interesting.

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

HENRY WYSOR, Metallurgical Editor.

PUBLISHED MONTHLY BY

THE CHEMICAL ENGINEER PUBLISHING COMPANY

355 Dearborn Street, Chicago

Entered as Second Class Matter, Aug. 19, 1907, at the Post Office at Chicago, Illinois, March 3, 1879.

Subscription—United States, Cuba and Mexico \$2.00
Extra postage to Canada 25c a year; to foreign countries 50c a year.
Remittances may be made by check, draft, or money order in favor of
THE CHEMICAL ENGINEER PUBLISHING CO.

All matter connected with subscriptions or advertising should be sent to
THE CHEMICAL ENGINEER PUBLISHING CO., 355 Dearborn street, Chicago.
Anything intended for the Editorial Department should be sent directly
to the Editor, Richard K. Meade, Allentown National Bank Bldg., Allentown, Pa.

NOTES AND COMMENTS.

Engineering Chemistry and the Chemical Engineer.

Certain principles have been studied and practically applied in the development of the locomotive, and men are trained to run it. Certain other principles, more manifold and more obscure to human perception, have been practically applied in the development of engineering chemistry, and special training is necessary to those who follow it as a profession. A concrete object is chosen for this analogy rather than mechanical engineering, since it brings more readily to the point two ideas, viz., that the upbuilding of a composite mechanism or craft foreshadows its operator or practitioner, and that mechanics is and has ever been recognized as a practical art, while the usefulness of chemistry was long doubted in the popular mind, and in the minds of many of its promoters the application of chemistry to commercial or practical ends was unworthy if not indeed degrading. Fostered as it was in the early days of superstition and practiced through the middle ages by philosophers, it is not unnatural that a kind of aristocracy should remain among chemists who look with disdain upon the modern commercial invasion. Let no one despise the achievements of even the most narrow-minded. Rather let it be conceded that no more noble motive has brought forth scientific light than that which has rendered service for the sake of science. Let glory be to whom glory is due, and in the reckoning of men and their work, let it not be overlooked that scholarly attainment and scientific devotion of the highest order is to be found among men in the ranks of industry, men whose work consists in the application of science to the needs of humanity. Chemistry, being a servant of man, can lose no more dignity as an ally of industry than as a pure science. This is an age in which all things are being turned to account in the conservation and usage of the world's resources. In this capacity chemistry has taken an important place, largely under the accepted term "Engineering Chemistry."

Engineering chemistry is involved in surveys, investigations and manufactures in which chemical and physical science are jointly applied. It embraces or is recognized in the majority of manufacturing

processes in which the products are subjected to chemical treatment. The nature of this treatment varies from a slight chemical action, as in the textile industries, to a complete transformation of the raw material, as in the manufacture of cement and in smelting ores.

Concerning productive activities in general, which are dependent more or less upon chemical principles, the importance granted to these principles is not always as sufficient as warranted. For the success of some enterprises the continuous services of a chemist are required; in others he is a valuable associate, since through his knowledge and skill processes are made more economical; again, he may be desirable in consultation, since his researches may open new avenues to profit. There are some industries, partly or largely chemical, in which no chemist is employed. Well-trodden paths are followed, obstacles are seldom encountered, and so long as nothing goes wrong which any good mechanic could not adjust, the questionable luxury of a chemist is happily dispensed with. Suppose, however, that aside from his special training in the mysteries of chemistry one may be found who has knowledge of mechanics, plant construction and operation, and the essential details of manufacture—one who is not simply competent to examine boiler water, determine by experiment the efficiency of fuel or report analyses of raw materials and products, but who can carry the laboratory test into the mill, measuring actual efficiencies and possible increases of efficiency, preventing or minimizing losses, increasing output and possibly lengthening the life of appliances. If, indeed, it is possible for a chemist to so enlarge his scope of experience, his day of usefulness is at hand.

There is a type of chemist, not the most common, whose representatives are filling prominent and useful places in the industrial world. On account of their ability to make of the plant a chemical laboratory in which the experiments work, they have been honored with the title "Chemical Engineer." This distinction seems warranted, since not all who are read or skilled in chemistry are versed in the mechanical arts. A chemist devotes his best energies to problems purely chemical, while a chemical engineer must meet the exigencies of plant construction and operation, making use of chemical principles when required. The one needs more general knowledge of chemistry and familiarity with chemicals, the other aptitude in special branches, while both should be thoroughly grounded in the principles of chemistry. One of the noblest tasks that is devolved upon the engineer and chemist lies in the attainment of the highest possible economy in the procuring, manufacturing and usage of exhaustible materials.

In the metallurgical industries very important work is required of chemical engineers. Perhaps no other branch of technology has called forth the efforts of such able men, and certainly none is marked by greater achievements. Historically, the arts of chemistry and metallurgy are inseparable. Trace back their his-

tories until they are lost in tradition, and it will be found that the two have ever been associated. Much of the future hope of metallurgy lies in the solution of chemical problems.

While it is true that the metallurgical industries have called forth the efforts of some of the great world leaders in the progress of industrial arts, it has apparently not attracted enough men of technical training. Recent years have, however, witnessed decided changes in this respect. They have also witnessed the promise and fulfillment of far greater possibilities by the supplanting of rule of thumb methods and untrained men by scientific methods and men of technical training. The demand for the chemist and his craft has steadily increased, and rapidly during the past 30 years. And this demand is not confined to analysts or to chemists of narrow training, but the more responsible calling is extended to the chemical engineer. Such positions as blast furnace manager, superintendents of foundries, steel works, every type of smeltery and refinery or metal extraction plant and even of mines and concentrators are being filled by high-priced experts, self-made or otherwise trained, instead of the "practical man" of former days. With the rapid growth of manufactures metallurgy has grown to gigantic proportions. The modern metallurgist stands upon the vantage ground of accumulated knowledge, but his is an age of closer competition and more enforced economy. Herein lies his need for thorough training, that he may the better apply the knowledge, which is his heritage, and the more successfully increase efficiency, which is his goal.

H. W.

Soldering Aluminum.

According to a recent issue of *The Ironmonger* the best soldering medium for aluminum is an alloy of that metal and tin. The proportions vary according to the extent to which the soldered articles are intended to be worked; 45 parts of tin and 15 of aluminum forming a good solder for such as are to be shaped afterwards. A harder solder, but less easily applied with the soldering iron, is prepared by melting $4\frac{1}{2}$ parts of red copper, to which are then added $3\frac{1}{2}$ parts of zinc and $4\frac{1}{2}$ of tin, the heating being continued until a homogeneous alloy is attained, which is cast into sticks. In the March issue of *The Metal Industry*, Wm. Hoopes states that the surface of all aluminum is covered with a thin invisible coating of aluminum oxide, and that this coating forms instantly after the surface is cleaned; it is very refractory and is soluble only in hydrofluoric acid. It is necessary, therefore, to remove this coating of oxide simultaneously with the soldering operation, and this is best accomplished mechanically by abraiding the surface with a steel or brass scratch brush while the solder on the surface is still molten. Higher temperatures are required for alloying aluminum with solder than with other metals; lead solders, consequently, are useless with aluminum.

BOOK REVIEW.

A COURSE IN QUALITATIVE CHEMICAL ANALYSIS OF INORGANIC SUBSTANCES, WITH EXPLANATORY NOTES. Olin Freeman Tower, Ph. D., Hurlbut Professor of Chemistry in Adelbert College of Western Reserve University. 8vo. 11 + 83 pages. Price \$1.00 net. Philadelphia: P. Blakiston's Son & Co.

The aim of this book is to treat the subject from a modern standpoint, to encourage the student not only to carry out accurately the mechanical processes of qualitative analysis, but also to apply some of the principles of modern chemistry in his practical work.

The introduction, covering 14 pages, contains a brief statement of the special principles derived from Physical Chemistry which are of most frequent application in qualitative analysis.

The analytical methods with few exceptions are the standard ones. The method of Noyes and Bray is used in separating antimony and tin. The basic acetate method is used for the precipitation of the Iron group. The directions are full and clearly stated. Explanatory notes are given on the page opposite the directions for the procedure in separating the groups. Very few equations for reactions are given, leaving this very properly for the student. No skeleton outlines are given.

The appendix contains articles on preparing solutions of reagents, optional method for precipitating the Iron-Zinc group, analysis of the Iron-Zinc group in presence of phosphates, and analysis of the Tin group when gold and platinum may be present.

INDUSTRIAL NOTES.

The Scientific Materials Company, of Pittsburg, Pa., have just issued a new edition of their catalogue of Laboratory Supplies, which is the largest and most complete catalogue of this kind ever published in the United States. In addition to being a most complete reference book of laboratory apparatus, it is compiled in such a way that reference can easily be made to any apparatus desired without the use of the index, as everything is listed in its natural alphabetical classification, and where two or more classifications suggest themselves, the book is cross-indexed.

It contains 3,000 different forms of apparatus used in laboratory work, every one of which is listed in all of the different sizes ordinarily used. There are 2,000 illustrations, every one of which appears on the same page with the corresponding description and price. All ambiguous terms have been eliminated, and where two or more items of the same name, but of different construction, are listed, the difference is brought out in heavy type.

This catalogue contains 538 pages, is bound in flexible cloth, and is hand-sewed. This book is being sent free of charge to chief chemists and professors of chemistry, on request.

INDUSTRIAL AND PLANT NEWS.

Alloys. The Syracuse Aluminum and Bronze Co., of Syracuse, N. Y., is building a foundry for the production of aluminium bronze and brass and aluminium castings. The building will be fireproof and will contain about 60,000 square feet of floor space. It is their intention to have a plant which will produce castings at the least possible expense and with model equipment in every respect.

Artificial Silk. Delphin M. Delmas, the well known California attorney, announced on his return from England, the early part of the month, that among his clients were a French firm, which intends to build in this country a large plant for the manufacture of artificial silk. Mr. Delmas has announced that it was his intention to secure a site for the proposed plant at an early date.

Ceramics. Mr. J. W. Bock of East Liverpol, Ohio, proposes to build a plant at Newell, W. Va., for the manufacture of porcelain wares. Three kilns will be erected at once together with grinding and molding departments. It is his intention to ultimately increase this plant very materially.

Chemicals. The General Chemical Company of New York, has let the contract for the first two buildings of its proposed large new plant at Newell, Pa. These buildings are to be of steel and brick with concrete floors. The contract specifies that they must be finished by December 22nd. It is the intention of the General Chemical Company to build at Newell, Pa., a plant which will ultimately cost \$3,500,000.

Chemicals. The Niagara Electro-Chemical Company, Niagara Falls, N. Y., is asking for bids upon factory and laboratory buildings of brick, reinforced concrete and steel. The buildings are to be 52 x 118 feet and 40 x 104 feet; two stories in height. The plant will be located on Buffalo avenue.

Chocolate. H. O. Wilbur & Sons, Inc., 231-235 North 3rd street, Philadelphia, Pa., will erect a reinforced concrete addition to their present factory, which will be six stories in height and 26 x 300 feet.

Coke. Contracts have been let by the Isabella-Connellsville Coke Company, of Brownsville, Pa., for their coke plant at that place. There will be 500 bee-hive ovens, the plant will take two years to complete and will cost approximately \$1,500,000.

Fertilizers. W. H. Robertson & Co., of Norfolk, Va., announced recently that they had purchased a tract of land on the Elizabeth River, near Money Point, and will shortly break ground on the new site for a large fertilizer factory.

Fertilizers. The Read Phosphate Company, Nashville, Tenn., have purchased the plant of the Hopkins Fertilizer Co., New Albany, Ind., and will greatly enlarge the latter. The improvements will cost something like \$25,000.

Iron. Electric furnace pig iron produced at the Heroult plant of the Noble Electric Steel Co. on the Pitt River, in Shasta County, California, is now in the San Francisco market in carload lots.

Lead.—The National Lead Co., Chicago, Ill., has awarded contracts for a new \$200,000 plant to be erected in Chicago. The plant will include 40 corroding stacks, a 110x54 ft. factory and a three-story warehouse, 60x170 ft.

Leather. The J. H. Ladew Company, with offices at 103 Park avenue, New York City, announce that they will build in the meadows at Newark, N. J., a plant for the manufacture of sole and belt leather, which will cost approximately \$150,000.

Lime. The Tidewater Portland Cement Company are having plans prepared for the erection of a lime and hydrated lime plant at Union Bridge, Maryland, where this company has a fine deposit of limestone suitable for the manufacture of the very highest grade of lime. Five improved kilns will be built and the hydrated plant will have a capacity of 600 barrels of hydrated lime per day. This latter plant will

be the most modern in the east, being equipped with automatic conveying devices. All buildings will be of concrete-stucco and steel.

Nitrate of Soda. Consul Alfred A. Winslow, Valparaiso, submits the following report in regard to the condition of the nitrate business in Chile:

"The nitrate business is badly disturbed over the dissolution of the nitrate combine that ended March 31, 1909. The price of nitrate has declined very materially, and several of the works have shut down. A strong effort is being made to agree upon some working basis, so as to control the market and keep up the price. The Chilean Government is taking a hand in the matter, since it is deeply interested, as there is an export tax of 50 cents United States gold per Spanish quintal of 101.42 pounds.

"On January 31, 1909, there were 145 separate nitrate works in Chile, and it is a very difficult matter to get all the interests together. There are several strong companies that own several plants each, and it is among these that the most opposition to combining is found."

Packing Plant.—The Cudahy Packing Co., of Omaha, Neb., has begun preparations for the construction of a plant in Calumet, Ind., between East Chicago and Indiana Harbor, to employ 2,000 men. About \$500,000 is to be expended at once on the erection of a group of buildings and for laying tracks and switches, and it is estimated that by the first of the year the factory will be in operation, providing employment for between 400 and 500 persons. This industry will represent only one feature of the plant to be located at this point. An establishment, in which the Cudahy people propose to manufacture the cars used in their business, and a sweet glycerin factory and a factory for the manufacture of wool felt for insulation purposes are planned.

Portland Cement. Announcement is made that plans have been completed for the consolidation in one company of all the cement companies in Canada. The new merger will include all the principal cement plants now in operation in Canada and will be known as the Canadian Consolidated Cement Company. It will have a capitalization of \$25,000,000.

Portland Cement. The Acme Portland Cement Company, of Spokane, Washington, has let the contract for the erection of its new mill to the Fuller Engineering Company, Allentown, Pa. The plant will have a capacity of 150,000 barrels per day and will cost between \$650,000 and \$700,000. It will be electrically operated and equipped with the most modern machinery for the manufacture of Portland cement.

Silk.—The Klots Throwing Co., Scranton, Pa., has awarded a contract for a new two-story and basement silk mill, to be erected at Forest City, Pa., at a cost of about \$35,000.

Soap. The Rome Soap Manufacturing Company, Rome, N. Y., will build a soap factory at that point. The buildings will be of reinforced concrete, fireproof, and with their equipment, will be valued at \$200,000.

Wood Preservatives. The Pacific Timber Preservative Company, Spokane, Wash., incorporated at \$100,000, has been formed for the purpose of manufacturing, producing and acquiring compounds for the preservation of timber, wood, steel, iron and other metals. A large factory for the manufacture of wood and metal preservatives will be erected at Spokane, Washington.

Wood Preserving. The Federal Creosoting Company, of Illinois, has let the contract for a plant at Toledo, Ohio. This will consist of three buildings, a retort structure, power house and combination office and machine shop.

Wood Preserving. The Pennsylvania Railroad has awarded the contract for the erection and equipment of a pressure wood preserving plant at Greenwich Point, near Philadelphia, Pa. The buildings will be 50 x 150 feet and fireproof. One cylinder will be erected at the present time. The plant will have a large storage yard and tracks and a capacity of 750,000 to 1,000,000 ties. It will be a duplicate of the present plant of the Pennsylvania Railroad, at Mount Union.

RECENT PATENTS.

The following recent patents relating to industrial and engineering chemistry are reported by C. L. Parker, solicitor of chemical patents, McGill Building, 908 G. street, N. W., Washington, D. C.

926,729. *Manufacture of Producer Gas*. William J. Crossley, Openshaw, Manchester, and Thomas Rigby, Fairfield, Manchester, England. July 6, 1909.

The process of manufacturing producer gas consists in subjecting the fuel to a primary combustion while being mechanically agitated, continuously and automatically passing the resultant coke to the gas producer proper and passing the primary products of combustion through the coke in the gas producer.

926,765. *Process for Bleaching and Preparing Straw from the Southern Palm*. Ethel Pickett, Lawhon, La. July 6, 1909.

The process of bleaching and preparing straw from the Southern palm for trimming for hats, for braids, belts, rugs, suit cases, traveling bags, baskets, etc., consists in first collecting the tender palm, stripping each leaf apart, washing clean, putting same into salt water enough to cover the leaves, boiling or scalding them until they turn color, then spreading them out in the sun and dew until bleached, then washing each piece with a cloth or sponge and water, using no soap, then shredding into shreds.

926,820. *Refractory Material and Process for Producing the same*. Charles L. Norton, Manchester, Mass. July 6, 1909.

The process of making refractory material consists in roasting a mixture of magnesium carbonate and a silicious sand until the carbonate is thoroughly calcined, mixing the calcined magnesium and sand with asbestiform fiber and hydraulic cement adding water to the aforesaid mixture of solids in quantities sufficient to form a wet pulp, and then subjecting the pulp to pressure while hydration of the cementitious materials is in progress expressing the surplus water and compacting the entire mass.

926,842. *Liquid-Treating Apparatus*. Kent W. Bartlett, Madison, Wis., assignor to Northern Water Softener Co., Madison, Wis., a Corporation of Maine. July 6, 1909.

The apparatus includes a liquid-receiving tank, a source of chemical supply for said tank, mechanism for governing chemical flow to said tank and operated by the liquid within the tank when the said liquid has reached a predetermined lower level, to renew the chemical flow to the tank, and restraining mechanism governed by the liquid in the tank for preventing the aforesaid mechanism from operating during the time the liquid in the tank is descending from one level to the other level.

926,843. *Liquid-Treating Apparatus*. Kent W. Bartlett, Madison, Wis., assignor to Northern Water Softener Co., Madison, Wis., a Corporation of Maine. July 6, 1909.

The apparatus includes a main supply tank, a constant level chamber for receiving liquid therefrom, a receiving tank for receiving liquid from the constant level chamber, and mechanism for governing the admission of liquid to the receiving tank and operated by the liquid within the main supply tank when the liquid within the main supply tank has reached a predetermined upper level to permit the flow of liquid from the constant level chamber to the receiving tank, and operable when the liquid in the main supply tank has predetermined lower level to cut off the supply of liquid from the constant level chamber to the receiving tank.

926,980. *Process for Making Alloys*. John T. H. Dempster, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. July 6, 1909.

The process for producing alloys consists in melting a quantity of nickel with a de-carbonizing agent in a clay lined crucible to reduce the carbon, adding iron and chromium in

suitable proportions, then adding manganese and pouring the mixture before the manganese attacks the clay lining.

926,999. *Process of Producing Digestible Substances from Keratin*. Carl Neuberg, Charlottenburg, Germany. July 6, 1909.

This is a process for converting keratin or keratin substances into digestible albumoses and peptones and consists in subjecting keratin substances to the action of mineral acids for a time and at a temperature to transform the keratin until a diluted sample of the reaction liquid to which a precipitant for albumoses has been added after filtration shows no amino-acid-nitrogen, whereupon the formed albumoses and peptones are isolated.

927,021. *Process of Treating Arsenical Ores and Speiss*. Anson G. Betts, Troy, N. Y. July 6, 1909.

This is a process of treating speiss and consists in dissolving it as anode in a solution of a salt of a metal depositable more readily than hydrogen, while depositing said metal on the cathode and utilizing the full cathode effect of the current in metal deposition, and recovering metal of the speiss from the solution.

927,046. *Method of Treating Ores*. Haseal A. Hogel, New York, N. Y. July 6, 1909.

This is a method of treating refractory ores and consists in subjecting the same to the action of heat in the presence of air, mixing sulphur therewith (unless there is enough sulphur in the ore) mixing salt therewith, heating the mixture in the presence of air to a degree sufficient to volatilize the metals or other compounds which it is desired to recover, passing the volatilized products into a condenser containing a liquid, intimately mixing said volatile products with said liquid and air, causing the liquid to repeatedly pass through the condenser, allowing the excess of air to escape from said liquid during its passage, cooling the liquid at one period of its passage through a part of said condenser, collecting the solid products deposited in said liquid, and treating the liquid and solid products to obtain the metals, lead, copper, silver, and gold in the usual way.

927,135. *Process of Making Acetate of Lime*. Robert W. Erwin, St. Louis, Mo. July 6, 1909.

This is a process of making acetate of lime and consists in evaporating a solution thereof in vacuum until the liquid reaches a specific gravity of substantially 1.08, continuing said evaporation in another vessel until the specific gravity of the liquid reaches substantially 1.12, further evaporating the liquid in an independent vessel until the specific gravity thereof reaches substantially 1.16 or at the point of crystallization, and subsequently drying said crystals in vacuum.

927,198. *Process for the Production of a Leather Substitute*. Rudolf Weeber, Vienna, Austria, Hungary. July 6, 1909.

This is a process for producing a leather substitute, and consists in adding fibrous material to a solution of balata, caoutchouc and gutta-percha, precipitating the agglutinant on the fibrous material, separating the fibrous material from the solution, adding an oil to make the fibrous material soft and flexible, and forming said material into a sheet.

927,283. *Metallurgical Furnace*. Robert G. Reilly, Corona, N. Y., assignor to North American Reduction Company, a Corporation of Arizona. July 6, 1909.

This is a metallurgical furnace and comprises the combination of a feed chamber for the ore; a combustion chamber; a movable grate mechanism at the bottom of said combustion chamber, adapted to support the ore; and means to reciprocate said grate mechanism while the furnace is in operation, substantially as described.

927,304. *Tire-Filling Compound*. Francis M. Willett, Indianapolis, Ind. July 6, 1909.

This is a compound for filling tires, consisting of a cooked mixture of one and one-half gallons of glue and one gallon of syrup, to which cooked mixture small quantities of glycerin and turpentine are added.

927,342. *Process of Recovering Sulphur*. Walther Feld, Zehlendorf, and Anton Jahl, Honningen-on-the-Rhine, Germany; said Jahl assignor to said Feld. July 6, 1909.

This is a process for obtaining sulphur from sulphur-dioxide and sulphureted hydrogen, and consists in passing these gases through liquid having the power of dissolving the sulphur as it separates.

927,374. *Process of Manufacturing Incandescent Mantles*.

Arthur Muller, Furstenwalde-on-the-Spree, Germany, assignor to the Firm of G. P. Drossbach & Co., Freiberg, Germany. July 6, 1909.

The mantles are manufactured by impregnating the fabric of the latter with a colloidal solution of an oxid-hydrate of a rare earth, substantially as described.

927,418. *Process of Manufacturing Gas from Wood*. Burdett Loomis, Hartford, Conn., and Hawley Pettibone, New Rochelle, N. Y., assignors to Power and Mining Machinery Company, a Corporation of New York. July 6, 1909.

This is a process of making fixed producer gas from wood, and consists in placing in the base of a cupola a regular body of hard carbon, then igniting and burning a body of wood on top of the hard carbon, drawing the resulting flame down through the hard carbon and heating it to incandescence, feeding wood as required and drawing air down into the body of wood and drawing the resulting flame, hot gases and vapors down through said body of incandescent hard carbon, thereby converting the vapors and carbonic acid into fixed combustible gas.

927,457. *Process of Bleaching*. Franc Fuhrmann, Berlin, Germany, assignor by mesne assignments, to L. Fred Neirath, Berlin, Germany. July 6, 1909.

The bleaching process consists in heating the goods to be bleached with a liquor containing magnesium perborate in presence of alkali salts of fatty acids.

927,644. *Process of Producing Oxides*. Henry L. Doherty, New York, N. Y. July 13, 1909.

The process of producing hydrated oxide of iron consists in oxidizing moist finely divided iron by a current of air until the observed temperature begins to rise, replacing the air by a current of air diluted to carry less than the normal amount of oxygen, the dilution being directly as such observed tendency to rise in temperature and finally finishing by a current of air as temperatures begin to sink.

927,678. *Preparation of an Alloy of Iron and Magnesium*.

Paul Rakowicz, Griesheim, Germany, assignor to the firm of Chemische Fabrik Griesheim-Elektron, Frankfurt-on-the-Main, Germany. July 13, 1909.

This is a method of alloying iron or steel with magnesium and consists in first passing iron or steel from the solid into a semifluid or thickly liquid state, then introducing magnesium into the thick mass.

927,758. *Process for Treating Silicates of Aluminum for the Purpose of Obtaining Valuable Products*. Alf Sindings-Larsen, Christiania, Norway. July 13, 1909.

This process comprises feeding material containing aluminum-silicate to one end of a long electric furnace and a mixing of iron and a reducing agent to the other end thereof, and passing an electric current between the electrodes extending into the furnace.

927,843. *Process of Making Alloys of Zinc With Copper*. Sterling Elliott, Newton, Mass. July 13, 1909.

The process of producing an alloy of zinc with copper, consists in first melting the zinc, then adding the copper to the molten zinc and raising the temperature to the melting point of the alloy which is to be produced or thereabout, which is less than the melting point of the copper and also less than the boiling point of the zinc.

927,916. *Process of Recovering Volatile Metals and Metalloids from Lead and Copper Slags*. Wilhelm Witter, Hamburg, Germany. July 13, 1909.

This is a process of recovering in the form of oxide volatile metals and metalloids, especially zinc, from metallurgical products and ores, and consists in bringing the products or ores, when in a molten liquid state, into close contact with incandescent carbonaceous matter in the presence of an air-current consuming the carbonaceous matter for reducing the metals and metalloids to be recovered, and for maintaining the reduction and volatilization temperature, reoxidizing the reduced volatile metals and metalloids, and causing the so-formed oxides to escape with the current of combustion gases.

927,950. *Process of Manufacturing Wood-Pulp*. Charles B. Clark, Bangor, Me. July 13, 1909.

This is an improvement in the process of digestively treating wood by the "sulphite process," so called, in a bath of digesting liquor contained in a digester to form wood pulp and consists in removing from the digester during the period of digestion an appreciable quantity of the bath containing resinuous matters and extractives of the wood for the purpose of recovering an appreciable portion of the bath after the passing of the resinuous matters and extractives into it upon a resolution of the wood, and afterwards continuing the process of digestion in the liquor left in the digester.

928,076. *Apparatus for Converting Volatile Hydrocarbons into Fixed Gas*. Harry F. Smith, Lexington, Ohio. July 13, 1909.

The apparatus for converting volatile hydro-carbons into fixed gas consists of a producer, a cooling and scrubbing means connected to the producer, an extractor connected to the cooling means for separating the gas and tar, a separator connected to the extractor for separating the tar from water and any foreign matter, and means for conveying the tar from the separator to the producer where it is converted into gas.

928,103. *Process of Manufacturing Gas*. Jamin Bazelle, Kirkwood, Mo., assignor of one-half to Henry Leschen, St. Louis, Mo. July 13, 1909.

The gas and illuminating gas are manufactured by alternately admitting and cutting off a supply of air to a bed of hot coal, passing the products of combustion of such coal through a separate mass of mineral carbonates and thence through a second mass of coal, and thence through a mass of refractory material, and collecting the fuel gas thus produced, and in passing the gas, which distills from the hot coal while the air supply is cut off, through said mass of carbonates and the second mass of coal, and then injecting volatile hydrocarbon into it and separately collecting the illuminated gas thus produced.

928,118. *Apparatus for Subjecting Gas or Vapors to the Action of Liquids*. Charles H. Fowler and Edward A. Medley, Great Crosby, Liverpool, England. July 13, 1909.

This is an apparatus for subjecting gas or vapor to the action of liquids, and comprises the combination of a closed chamber, a vertical shaft, a set of horizontal disks rigidly carried by said shaft, and fixed only a short distance from each other, and means for supplying each of the disks near the center with a substantially equal part of the liquid supplied and means for passing the gas to be treated through the apparatus and past the peripheries of these disks.

928,235. *Process of Making Patent-Leather or Artificial Patent-Leather*. George R. de Montlord, Boston, Mass., assignor to the Hyde Leather Mfg. Co., New York, N. Y., a Corporation of Delaware. July 13, 1909.

The process of making patent-leather or imitation patent-leather, consists in preparing a solution of nitro-cellulose, a solvent, a vegetable oil, alcohol, glycerin, spirits of turpentine, and a suitable pigment or dyestuff, immersing the leather or fabric into ethyl acetate, coating the surface of a glass-plate with one or more layers of the same solution, uniting the leather or fabric with the coatings on the glass-plate by pressure, then drying the leather or fabric while

on the glass-plate, and finally removing the coated leather or fabric from the glass-plate.

928,176. Process of Manufacturing *Silicon Nitride*. Alf. Smiding-Larsen, Christiania, Norway. July 20, 1909.

The process for the production of silicon nitride, consists in producing vapors of silicon and causing the same to be acted upon by gaseous nitrogen in heated condition.

928,512. Process of and Apparatus for *Burning Cement and Like Materials*. Byron E. Eldred, Bronxville, N. Y., assignor to The Eldred & Palmer Company, N. Y., a Corporation of New York, N. Y. July 20, 1909.

The process of calcining calcareous materials comprises mixing air with products of combustion and combustible gas in controlled proportions and causing the mixture to undergo combustion in proximity to pulverulent calcareous materials contained in a hot-walled zone.

928,545. Process of Making *Nitric Acid*. Friedrich L. Schmidt, Charlottenburg, Germany. July 20, 1909.

The process of making nitric acid consists by causing sulphuric acid in molecular proportions to react on nitrate of calcium and separating the nitric acid thus obtained from the sulphate of calcium by filtration and afterward washing the sulphate of calcium with dilute nitric acid and water.

928,531. Method of *Refining Iron*. Paul Sejourne, Paris, France, assignor to Societe Electro Metallurgique Francaise, Froges, France. July 20, 1909.

The process of obtaining decarburized iron, consists in cooling low carbon steel from a molten condition until it is at least in part solidified, and the carbon therein has been oxidized by the contained oxygen and the oxid or oxides of carbon driven off, and remelting in the absence of carburizing conditions.

928,580. Process for Producing *Incandescent Mantles*. Georg Buhlmann, Gross-Lichterfelde, near Berlin, Germany. July 20, 1909.

This is a process for the impregnation of incandescent mantles consisting in dissolving a salt of an illuminating rare earth metal, adding to said solution a substance capable of reducing the acidity of said solution, shaking said solution in order to redissolve the precipitate, repeating the addition of the substance for reducing the acidity and shaking until the precipitate formed can no longer be dissolved and dipping the mantle fabric in the impregnating bath so formed.

928,734. Process for the *Electrolysis of Alkali Chlorides*. Jean Billitzer, Vienna, Austria, Hungary. July 20, 1909.

This is a process for electrolysis of alkali chlorides, comprising the compelling a part of the cathode product to form a thin layer in the electrolyte and the constant removal of said layer as it is formed.

928,844. *Manufacture, Concentration, and Simultaneous Purification of Sulphuric Acid*. Gaston C. De Briailles, Paris, France. July 20, 1909.

This is a process of manufacturing sulphuric acid from sulphurous acid by electrolysis of a solution of sulphurous acid by keeping the solution at substantially the same specific gravity as the solution of sulphurous acid by adding the requisite quantity of sulphuric acid.

928,971. Process of Obtaining *By-Products from Gases*. Gustav Hilgenstock, Dahlhausen-on the Ruhr, Germany. July 27 1909.

This is a process for obtaining by-products from gases of dry distillation of coal and other materials and consists in dividing the first quantities of gases from the retorts or coke ovens, containing the greater part of the tar yield from the latter quantities of the gas from the retorts or coke ovens, containing relative little tar, removing the tar from the said first quantities of gas and then combining the substantially tar-free gas so produced with the said latter quantities of the gas.

929,131. Prepared *Carbide of Calcium*. Xavier Herme, Fruitvale, Cal. July 27, 1909.

This is for a new article of manufacture and consists of a prepared carbide of calcium produced by mixing one part of sugar and one hundred parts of carbide of calcium; then successively mixing with said substances one-fourth of one part of petroleum, one part of sugar, four and one-half parts of glucose, and two and one-half parts of sugar.

929,152. Method of Making *Cement, Mortar, and Concrete Waterproof*. Paul Mecke, Stettin, Germany. July 27, 1909.

The method of making watertight concrete and mortar, consists in adding to the cement or lime mixture a pulp produced by the transposition of basic oleate of lime with sulphate of aluminum.

929,219. Method of *Treating Aluminous Materials*. Aldus G. Higgins, Worcester, Mass. July 27, 1909.

The method consists in fusing an aluminous material in an electric furnace at a temperature substantially above the state of quiet fusion and sufficient to prevent substantial segregation of impurities, and recovering the resulting product in solid form.

929,276. *Electrolytic Diaphragm* and Method of Making the same. Anson G. Betts, Troy, N. Y. July 27, 1909.

The method of preparing asbestos board for use as a diaphragm in aqueous electrolysis, consists in cementing together the fibers of the board by means of an easily fusible substance insoluble in the solution in which the diaphragm is to be used.

929,350. *Leuco Derivatives of Gallocyanin Arylids, Etc.*, and Process of Making Same. Charles Vaucher, Basel, Switzerland, assignor to the firm of Dye-Works formerly L. Durand, Huguenin & Co., Basel, Switzerland. July 27, 1909.

The process for the manufacture of leuco derivatives of gallocyaninarylids and of their sulphur derivatives, consists in heating the gallocyaninarylids and their sulphur derivatives in an indifferent medium, with reducing agents in the absence of an excess of an acid capable to split off the aminoaryl group.

929,383. Process of the Manufacture of a *Disinfectant*. Alexander Brick, Vienna, Austria-Hungary. July 27, 1909.

This is a process of manufacturing a disinfectant, consisting in mixing a soap solution containing alcohol with etheral oils, adding formaldehyde to this mixture, heating this mixture combined with formaldehyde, allowing this mixture to cool, and adding to the cooled mixture incompletely saponified oils containing alcohol.

929,442. *Anthracene Dye* and Process of Making Same. Max

H. Isler, Mannheim, Germany, assignor to Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany, a Corporation of Germany. July 27, 1909.

The process of producing anthraquinone coloring matter is effected by heating a beta-halogenated 2,2'-dimethyl-1,1'-dianthraquinonyl body containing the halogen in the opposite ring to that containing the methyl group.

929,517. Method of *Treating Aluminum Ores*. Frank J. Tone, Niagara, N. Y., assignor to The Carborundum Company, Niagara Falls, N. Y., a Corporation of Pennsylvania. July 27, 1909.

This is a process of treating aluminum ores and consists of making a mixture of aluminum silicate, emery and carbon, the amount of carbon being sufficient to reduce the silica and all compounds in the mixture except alumina, but insufficient to reduce the alumina, interposing this mixture as a resistance conductor between electrodes, passing current through the same sufficient to fuse the alumina and reduce the other constituents to metallic form and keeping the temperature of the charge below the reduction temperature of alumina.

929,518. Process of *Treating Aluminum-Silicate Ores*. Frank

The Chemical Engineer

PUBLISHED BY

The Chemical Engineer Publishing Co., 355 Dearborn St., Chicago

Vol. X.

OCTOBER, 1909.

No. 4.

THE TECHNOLOGY OF SALT MANUFACTURE.*

By G. P. GRIMSLEY.

Assistant Geologist, West Virginia Geological Survey.

While most of the salt in United States is obtained by evaporation of brines, a certain quantity is obtained by mining of rock salt. The processes of salt manufacture may be grouped under the following heads:

1. Mining of rock salt.
2. Solar evaporation.
3. Direct fire evaporation.
4. Steam evaporation.

entry or gallery is driven from which rooms are worked 30 feet square with 30-foot square pillars of salt left to support the roof. The best portion of the vein is selected for working, leaving 5 or 6 feet for roof and 4 feet for floor, so that the rooms in these mines are 14 feet high. Holes are drilled four to six feet into the salt above and blasted down with dynamite exploded by electricity, bringing the salt down in lumps or blocks in large quantity.

The larger blocks are broken by sledges and loaded into two-ton mine cars which are pushed to the bot-



Plant of the Liverpool Salt & Coal Co., at Hartford City, Mason County, W. Va.

5. Vacuum pan evaporation.
1. Mining of Rock Salt.

In 1906 the total salt production of the United States was 28,172,380 barrels, of which 4,873,526 barrels were rock salt according to the United States Geological Survey.

In New York state² the rock salt mine shafts are 12 x 18 to 24 feet square, well timbered and cemented to shut out water. At the bottom of the shaft a main

tom of the shaft and hoisted to the top of the salt works. The salt blocks are then dumped into breakers and broken into small pieces which pass down over a series of screens separating it into the different commercial sizes. In the Kansas mines nine sizes are separated and sold. The larger and more impure lumps weighing 5 to 50 pounds are used by the stockmen for cattle, the lumps being placed out in the open fields where they will remain some months. A very pure grade of small cubes three-fourths inch square is obtained by hand picking by boys and girls selecting the

*From West Virginia Geological Survey, Vol. IV.

²Englehardt, New York State Museum, Bull. No. 11, p. 36.

pure and uniform size crystals, throwing aside discolored cubes. This grade is sold as capping-salt, being placed in the bottom and top of barrels of pork and beef for exportation. The large packing houses of the West secure this grade from the Kansas mines. The next grade of salt cubes, a fourth to a half inch, is used in refrigerator cars, using about 500 pounds to the car. Other smaller sizes and the crushed salt are used for salting hides, manufacture of soda ash, and caustic soda, for ice cream manufacture, salting meats, etc. The finest salt is sold for domestic uses, but is not in as good demand as evaporated salt.

2. Solar Evaporation.

Where salt is made by evaporation of sea water in salt lakes, the brine is conveyed to open trenches, shallow ponds, or pans, and evaporated by the heat of the sun. This method is also used in the manufacture of salt from brines obtained from salt wells, and is a common method of manufacture near Syracuse New York. The following account of this method of obtaining salt from brine by the heat of the sun is taken from the report of F. E. Englehardt.³

The solar or coarse salt is made by the evaporation of brine in shallow wooden vats provided with movable wooden covers for protecting against rain. There are three sets of these vats or rooms, the first called the deep rooms, 12 to 14 inches deep, which receive the brine from the wells. In these vats the carbonic dioxide gas escapes and the iron is precipitated giving the brine a reddish color, but on complete precipitation of the iron, the liquid becomes clear.

The brine from the deep rooms is drawn into the lime rooms where evaporation continues until salt begins to crystallize; and if gypsum or lime sulphate is present, it begins to separate. The brine is now conducted to the third set of vats, the salt rooms, where the remaining gypsum crystallizes, and the salt crystals accumulate on the floor of the vat. The supply of concentrated brine from the lime or pickle vats is renewed from time to time, and when a sufficient quantity of salt has accumulated, it is raked to one side or harvested, drained and removed to the store house. It may be sold unscreened as Standard Coarse, or it may be screened over coarse screens and sold in two grades at Syracuse under the names Diamond Coarse and Diamond Fine.

In a Syracuse salt yard, according to Englehardt, two-thirds of the vats are salt rooms which are 18 feet wide, with a length of 100 to 500 feet, depending on the size of the plant, and 6 inches deep. The vats are built so that the floor of the first one is 6 or 8 inches higher than the second and so on for the different vats. The movable covers are in 16-foot section, which cover a space of 16 x 18 feet, or 288 square feet.

In later years an improvement was introduced in the use of aprons in place of the deep and lime rooms. These aprons are shallow vats, 20 to 100 feet wide,

200 to 2,000 feet long, and about three inches deep. Upon these the brine in a layer one-half inch deep flows slowly down a grade of one inch in 100 feet and is delivered saturated to the salt rooms. Storage tanks under the aprons are used and the brine is rapidly concentrated by the sun's heat and air currents, giving greater capacity to the plant. According to Charlard,⁴ the capacity of a salt room or vat, 16 x 18 feet, has been increased from 50 bushels a season to 70 or 80 bushels by use of aprons, and in one case was increased to 92 bushels.

According to Englehardt (p. 44), "the quality of the salt depends on the weather to a certain extent, but mainly on the intelligence and care of the workmen. Supplying the salt rooms with perfectly saturated pickle, allowing the harvested salt to drain properly both in the tub and the storehouse and finally to discharge the old pickle at the proper time, are of the utmost importance in the manufacture of a good commercial salt."

Mr. Englehardt states in his report of 1893, that there are at Syracuse, over 12,000,000 square feet of evaporating surface capable of producing 3,500,000 bushels of solar salt in a season which usually extends from the middle of March to the middle of November.

3. Direct Fire Evaporation.

Kettle Method.—Salt brines are evaporated by artificial heat applied to either kettles or pans containing the brine. In the first method,⁵ a kettle block consists of 60 to 100 hemispherical cast iron kettles suspended in two parallel flues ending in a stack, 50 to 100 feet high. The kettles are 22 to 26 inches deep and 3 to 4 feet diameter, with a capacity of 100 to 150 gallons. The flues are lined with fire brick and reach to within one foot of the bottom of the kettles, but farther back the bottom of the kettles is in direct contact with the flues and the hot gases of combustion. The brine is settled removing the iron and dirt impurities and then is conveyed in pipes to the kettles.

A shallow bittren pan is inserted in the kettles at first to collect the sulphate of lime, which is removed and thrown to one side until evaporation has gone far enough for the crystallization of salt. The salt is removed from time to time into baskets and after drawing is taken to the store house. The front kettles are drawn every four to five hours while the back kettles may require 24 to 36 hours. In five to six days the kettles must be cleaned of sulphate of lime, which forms a non-conducting incrustation on the bottom, thereby increasing fuel consumption. The time of operation of a kettle salt block is 10 to 15 days, so that two runs are made a month. About 45 to 50 bushels of salt are made with a ton of slack coal at Syracuse.

Chatard⁶ states that this is the original Syracuse method of evaporating brine and arose from the use

¹U. S. Geol. Survey, 7th Annual, p. 567.

²Englehardt, loc. cit., p. 49.

³U. S. Geol. Survey, 7th Annual, p. 507.

New York State Museum, Bull. 11, p. 39

of the potash kettle, the largest boiling apparatus known to the early salt makers who first used it in 1788. Later the kettle was set in an arch of stone, and in 1793, four kettles were combined forming a salt block. In 1860 the method was used at Saginaw, Michigan. It was also used in the Kanawha Valley of West Virginia and in some of the early Ohio plants, but it has now been practically abandoned in all these places.

Pan Method.—In the pan method of evaporated salt, the brine is pumped from wells into large storage tanks and from these flows down into the pans which are made of wrought iron plates, about one-half inch thick, riveted together. They are usually 20 to 25 feet wide, 80 to 100 feet long, and 12 inches deep, separated into two parts by a thin partition, over which the brine, slightly heated in the cooler portion of the pan, passes into the main portion where evaporation is completed.

The fire-box or grate is five or six feet below the bottom of the pans, and is separated by a brick arch which is more or less broken to permit the heat to pass through and yet to protect the pan from the intense heat of the fire. Along the side of the pan is the sloping drip board to hold the salt. The temperature of the brine is kept at about 200° F., and when a sufficient quantity of salt has accumulated it is raked to the drip boards where it drains. The hand rakes have long handles attached to a cross strip of steel 6 to 18 inches. The drained salt is removed to the store house and piled in compartments where it remains 30 to 60 days to dry, when it is packed in sacks, barrels, or loaded in cars in bulk.

The gypsum or sulphate of lime accumulates on the floor of the pans where it forms a hard scale, and being a non-conductor of heat soon lowers the temperature of the brine and decreases the output. It also tends to concentrate the heat on bottom of the iron pan, which buckles and may even break. This hard scale is broken by crowbars and pried off in cakes, which are removed to the waste piles. Outside of the West Virginia and Pomeroy, Ohio, salt brines, gypsum is in this way a most troublesome impurity.

Englehardt⁷ states that the great advantage of the pan process over any other is in the control over grain of the salt. If a fine-grained salt is desired, the fires are increased, causing the brine to boil and the crystals forming rapidly are small in size. The addition of butter, especially prepared soft soap, or white glue, forms a film over the surface of the brine and aids in making a very fine-grained salt for table use. Such salt is removed once an hour, while coarser grades are removed in 2 to 12 hours, according to the size of grain. Low fires and longer time permit the salt to form in larger crystals making the coarse grades. The temperature of the brine may thus vary from 212° to 145° F.

Englehardt found from his study of the New York practice that with coal slack and good weather, one ton

of coal was sufficient for 80 to 90 bushels salt in summer season with saturated brine, but in winter would make only 68 bushels, with a yearly average of about 72 bushels.

4. Steam Evaporation.

An attempt was made in New York to improve the kettle process by enclosing the iron kettle in steam jackets which increase the production from 45 or 50 bushels to 65 bushels to the ton of coal in the Warsaw district. The heat being uniform, the salt produced in the different kettles from front to back of the block was uniform in grain and quality.

Grainer Process.—In the grainer or Michigan process steam is driven through a set of pipes placed in the wood or iron vats, in transverse or longitudinal direction, thus furnishing heat for the evaporation of the brines. The process proved especially valuable in Michigan in conjunction with the sawmills where the exhaust steam was available by day and live steam direct from the boilers by night, lowering materially the fuel cost. This method was also found valuable in working the weak brines of the Kanawha and Ohio Valley regions.

The vats or pans in the New York grainer plants⁸ are 100 to 150 feet long, 12 feet wide, 20 to 24 inches deep, and contain 4 to 6 steam pipes with a diameter of 4 to 5 inches and suspended 4 to 6 inches above the bottom. The salt is removed by rakes every 24 hours, or automatic rakers move the salt constantly from front end of the grainer to the back where it passes up over an apron and falls into a conveyor which carries it to the salt bins.

The temperature is kept near the boiling point to secure the best results and brine is constantly supplied. The liquor remaining in the vats contains the bitter salts and becomes more and more concentrated. This bitter liquor still contains a considerable percentage of salt, so it is removed from time to time to another set of grainers where the balance of the salt is precipitated, usually coarse in grain and more or less impure, but is sold for cheaper uses. The brines before passing into the grainers are settled to remove iron and other impurities in the same manner as in the ordinary pan or kettle methods.

The lime sulphate or gypsum collects on the steam pipes forming a hard coat or scale. It is removed by increasing the steam pressure and heating the pipes which expand and crack the gypsum scale which is then readily removed. In the New York plants with grainer process, one ton of coal slack will produce 70 bushels of salt when saturated brines are used, and in Michigan 72 to 75 bushels. The Kanawha grainer system which differs in many respects from the New York and Michigan systems, will be described in the next chapter.

Chatard⁹ states that the capacity of grainers is usu-

⁸New York State Museum, Bull. 11, p. 59.

⁹U. S. Geol. Survey, 7th Annual, p. 520.

⁷Loc. cit., p. 48

ally reckoned by the number of square feet of grainer surface required to produce a barrel of salt in 24 hours, obtained by dividing the total number of square feet by the daily production in barrels. He states that the Saginaw, Michigan, exhaust steam blocks average one barrel of salt to every 32 to 36 square feet of grainer and to every 2.5 horsepower of boiler capacity. In the Kansas plants one barrel of salt is produced to 20 to 25 square feet of grainer.

5. Vacuum Pan Evaporation.

In the vacuum pan process, the brine is evaporated by steam with a reduced atmospheric pressure over the brine. The vacuum pan is a tall cylinder in which a reduced air pressure is maintained, lowering the boiling point of the brine, thus giving a more rapid evaporation and a finer grained salt.

Englehardt¹⁰ states that in the New York vacuum pans, the steam is conducted through the cylinder in 17 or 18 groups of copper tubes 20 tubes in each group. The salt crystallizing falls to the bottom and is automatically removed and screened, while fresh brine is supplied above.

Brownocker¹¹ states that in the Wadsworth, Ohio, plant there are two vacuum pans used, each of which is 40 feet high and 10 feet in diameter containing 800 evaporating tubes, 2½ inches diameter and 4 feet high. In the center of this group of tubes is a large one 24 inches diameter and 6 feet long, and the average temperature is 135° F. The vacuum is usually at 25 inches pressure maintained by an air pump and by the condensation of steam produced by the evaporation of the brine. One of the pans at the Rittman, Ohio, plant has 1,004 tubes 4 feet long and 2½ inches diameter, with central tube 4 feet long and 2½ feet diameter.

Impurities in Brine.

The following analyses by Dr. Goessman of New York brine and the pickle resulting from its concentration, are quoted by Englehardt (p. 41). They show the loss of iron carbonate, decrease of lime sulphate, and proportional increase in percentage of salt, and the soluble lime and magnesium chlorides:

	Brine.	Pickle.
Specific gravity	1.1225	1.2062
Lime sulphate	0.5772%	0.4110%
Lime chloride	0.1533%	0.2487%
Magnesium chloride	0.1444%	0.2353%
Potassium chloride	0.0110%	0.0194%
Magnesium bromide	0.0024%	0.0039%
Ferrous carbonate	0.0044%	0.0000%
Sodium chloride (salt)	15.5317%	25.7339%
Water	83.5747%	73.3488%

The lime sulphate is absent in the West Virginia brines on account of the presence of barium, but in most American brines, there is an absence of barium, and the presence of a considerable percentage of sulphate of lime which is a source of trouble as shown

above in the different methods of evaporation of brines. It can readily be precipitated in the laboratory by a number of reagents, but such methods are found to be too expensive for use on a commercial scale.

The chloride of magnesium according to Chatard (p. 504) tends to make the salt fine grained, sharper in taste, and more rapidly soluble. Such salts containing this compound as made in the Kanawha and Ohio river regions are preferred for curing meats in warm climates.

The strength of brine is indicated by the specific gravity. A saturated brine at 60° F. has a specific gravity of 1.2055 and contains 26.47 per cent of common salt. The strength may also be indicated by the salometer, which is a short glass tube so weighted that the point to which it sinks in pure water is marked 0 on the scale, and the point to which it sinks in a saturated brine at 60° F. is marked 100. The presence of lime and magnesium salts increase the readings, and a rise in temperature will lower the reading. Englehardt states that for all practical purposes it is sufficient to add or deduct one degree to or from the reading for every 10 degrees the temperature is above or below the normal.

By-Products from Salt Brines.

In the Kanawha valley and Ohio river valley of West Virginia and Ohio near Pomeroy, the salt brines carry two important by-products, bromine and calcium chloride. The Michigan and Allegheny, Pennsylvania, brines also carry bromine. On account of decline in price of bromine, the industry is not as valuable as some years ago.

Bromine Manufacture.—According to the reports of Merrill in U. S. Geological Survey Mineral Resources, Pennsylvania was the pioneer state in the manufacture of bromine, where the industry started at Freeport, in Armstrong county, in 1846. The Ohio industry began at Pomeroy in 1808 and at Canal Dover, Ohio, in 1888, but was abandoned at the latter place. The bromine industry was started by Mr. Lerner at Mason City, and above Charleston, West Virginia, about 1872, and in Michigan in 1883.

The Midland, Michigan, brines are said to contain four times as much bromine as those from other localities. According to Mr. Joseph Struthers,¹² thirteen companies were organized to produce bromine from the Midland brines since 1883, but in 1903 there were only two operating companies. He gives the following list of bromine producing companies in the United States in 1903:

Dow Chemical Company, Midland, Mich.

Meyers Bros. Drug Company, Midland, Mich. (office St. Louis, Mo.)

Independent Chemical Co., Saginaw, Mich.

Wayne Chemical Co., Saginaw, Mich.

John A. Beck & Co., Allegheny, Pa.

Syracuse Coal & Salt Co., Syracuse, Ohio.

¹⁰Loc. cit., p. 61.

¹¹Ohio Geol. Survey, Bull. VI, p. 30.

¹²Mineral Industry, Vol. XI, p. 73; 1903.

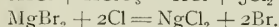
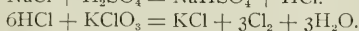
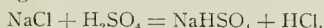
Coal Ridge Coal & Salt Co., Pomeroy, Ohio.
 Buckeye Salt Co., Pomeroy, Ohio.
 Excelsior Salt Co., Pomeroy, Ohio.
 United Salt Co., Pomeroy, Ohio (no output since 1900).

Dickinson & Co., Malden, W. Va.
 Hope Salt & Coal Co., Mason City, W. Va.
 Liverpool Salt & Coal Co., Hartford, W. Va.
 Hartford City Salt Co., Hartford, W. Va.

The brines at the above localities except Midland have practically the same composition. On average 360 gallons of brine are required for one barrel of salt, and brine for 100 barrels of salt yields 55 pounds of bromine, though at Pittsburg the yield has been as high as 75 to 80 pounds to 100 barrels of salt.

Except at the plant of the Dow Chemical Co., all use the same process. Sulphuric acid and potassium chlorate are added to the brine in stone stills of 400 to 800 gallons' capacity, and the liquid agitated by steam jets under 40 pounds' pressure. By the Dow process, the Michigan brine containing 0.1 to 0.2 of 1 per cent of bromine has this element freed from its alkaline bases by an electric current, and the free bromine is removed from the brine by a current of air blown through it, and absorbed from the air by caustic soda. In 1903, one-half the bromine production of United States, according to Struthers, was made by the Dow process at Midland.

According to Merrill,¹³ the sulphuric acid produces from the bitter enough hydrochloric acid to act on the potassium chlorate liberating enough chlorine to free all the bromine. On application of heat, the bromine is liberated. The reactions are given by Merrill in the following formulae:



More or less chlorine is carried off with the bromine, often as much as 10 per cent, so the bromine is later redistilled.

The price of bromine in the past few years has ranged around 28 cents a pound. The following table of statistics compiled from the reports of the U. S. Geological Survey shows the total production of bromine in the United States and in West Virginia, but since 1902 the statistics have not been given by states:

	Total Production, Pounds.	W. Va., Pounds.	United States, Value.	Price Per Lb. Cts.	Rank of W. Va.
1898.....	486,979	118,888	\$126,614	28	Third
1899.....	433,064	101,213	108,251	29	Third
1900.....	521,444	114,270	140,790	27	Second
1901.....	552,043	106,986	154,572	28	Third
1902.....	513,893	93,375	128,472	25	Fourth
1903.....	598,500	.....	167,580	28	
1904.....	897,100	.....	269,130	30	
1905.....	1,192,758	.....	178,914	15	
1906.....	1,283,250	.....	165,204	12.8	
1907.....	1,379,496	.....	195,281	14.0	

The producing localities in 1906 were Midland, Mount Pleasant, St. Louis, Michigan; Pomeroy, Ohio;

Allegheny City, Pennsylvania; Hartford, Mason and Malden, West Virginia. According to the U. S. Survey, the decline in price is due to the imports of this material from Germany.

Bromine is used¹⁴ in manufacture of bromides of potassium, sodium, and ammonia for medicine and photography. A small amount is used in the manufacture of the coal tar colors, eosine and Hoffman's blue. It is used as a chemical reagent, as a disinfectant dissolved in water, also for bromocyanide process of gold extraction.

The manufacture of calcium chloride will be described under the description of the West Virginia salt plants.

NOTES ON THE MANUFACTURE OF CARBURET- TED WATER GAS BY THE LOWE PROCESS.*

By CARL F. SCHOEN.

HISTORY.

The fact that water can be decomposed by contact with incandescent carbon was known more than one hundred years ago. An Italian, named Fontana, published in 1780, the results of his experiments in the dissociation of steam. The water gas referred to by Fontana had no illuminating value and for many years was only a laboratory curiosity. During this time, the use of coal gas as a means of illumination was rapidly spreading.

Commencing about the year 1824, numerous efforts were made to carburet non luminous water gas and so fit it for illuminating purposes. During the next thirty years more than sixty patents were taken out. None of these inventions attained commercial success, because materials suitable for carbureting economically were not available and because no method of carbureting was known which would produce a thoroughly fixed, non condensable gas. The discovery and development of the vast oil fields of Pennsylvania and Ohio and the invention by T. S. C. Lowe of the "generator superheater" process made possible the successful production of water gas on a commercial scale.

During the Civil War, Lowe, while engaged in making and using balloons for the United States Government, experimented with methods of making water gas. Later, he conceived the idea of vaporizing petroleum in the presence of the hydrogen and carbon monoxide formed by the dissociation of steam in contact with incandescent carbon, in a vessel previously heated by the products of combustion formed while bringing the mass of carbon to the temperature of dissociation. Lowe presented his idea early in the seventies. His patents were dated 1872 and 1875. In its earlier years the water gas system was slow of growth. While the principles involved can be stated in a very few words, years of thought and labor were

¹³Merrill, U. S. G. S. Mineral Resources, 1904, 1905.

*Thesis for the Degree of Bachelor of Science in Chemistry. Lafayette College, Easton, Pa.

¹⁴U. S. Geol. Survey, Min. Resources, 1905; p. 1907.

spent before the mechanical details of a complete and successful apparatus were evolved.

STATUS OF WATER GAS MANUFACTURE.

In 1882 the Lowe process came under the control of "The United Gas Improvement Company," and became the subject of systematic study and experiment on the part of its engineers. Since that time, owing to the economies effected in the operation, the use of carburetted water gas has rapidly increased. About seventy per cent of the illuminating gas used to-day is water gas. It is estimated that there are 60,000 millions of cubic feet of illuminating gas manufactured in the United States annually. About 42,000 millions of cubic feet of this is water gas, supplying a population of 11,720,782 in fifty-eight cities of over 50,000 inhabitants, while the population of seven cities which do not use water gas is only 689,553. From this it appears that ninety-four per cent of the aggregate population of cities of over 50,000 inhabitants is supplied with water gas.

LOWE PROCESS APPARATUS.

The principal part of the gas-making apparatus consists of three upright, cylindrical vessels, whose outer walls are of boiler plate and whose interior structure is of fire brick. All are connected for the passage of gas by short conduits. The vessels are known respectively as the generator, carburetter, and fixing chamber or superheater. The generator is a water gas producer, arranged for the introduction of steam into the fuel bed from either the top or the bottom. The top of the generator is on a level with the working floor. The carburetter, besides its lining of fire-brick has checker-work of fire-brick filling its interior. This serves to mix the gases in their passage and expose a large surface area for heating them. There is pipe connection through the top of the carburetter for introducing the carburetting oil in the form of spray. An opening is provided near the top for admitting air, while the brick work is being heated by combustion of gas from the generator. The carburetter stands on a level with the generator and is of about the same size.

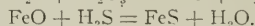
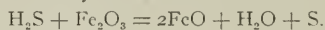
The construction of the superheater is similar to that of the carburetter, consisting of a lining of fire brick and the interior filled with checker work. At the top of the superheater is placed a quick opening stack valve through which the products of combustion escape into the air during the blows. In the take off pipe leading from the top of the superheater to the washer, is located an oil heater designed to preheat the oil before it enters the carburetter. This heater can be by-passed when repairs are necessary and is so arranged that it can be easily cleaned. The shells of both the carburetter and superheater are provided with a number of man holes for convenience in cleaning and replacing the fire brick.

The other equipment of a gas plant includes a washer, a scrubber and a multitubular water condenser, also a boiler, horizontal engine, special fan

blower, oil pumps, oil meter with vertical dial, oil injectors, differential pressure gauges and test light purifiers, tar and drip wells and a separator, purifiers for the gas and the necessary storage holders.

The washer consists of a boiler plate shell filled with water through which the gas bubbles. This condenses some of the tar and partly cools the gas.

The scrubber is a shell constructed of boiler plate, containing horizontal wooden trays over which cold water drips. The hot gas passes upward and the water downward. The gas purifiers consist of large boiler plate tanks filled with trays containing wood shavings impregnated with hydrated oxide of iron. The gas passing through this "oxide" is freed from hydrogen sulphid by the well known reactions:



The tar well is a large cistern which collects all the tar condensed in the apparatus together with the water used in condensing and washing. In the drip well is collected the tar and water which is condensed in the pipes leading to the storage holders. From these two points, the mixture of tar and water is siphoned to the separator.

The separator is a large rectangular tank through which the mixture slowly flows. While passing through the separator the tar settles out from the water and is collected for further use. In order to facilitate the separation, the separator contains latitudinal partitions. The alternate partitions are slightly higher than the surface of mixed tar and water and these partitions do not reach to the bottom of the separator. This arrangement causes the liquid to flow over one partition and under the next one in front of it, forcing the mixture to traverse a much longer distance than it would by passing in at one end of the separator and out the other.

Besides the apparatus named, the plant at which the work for this thesis was conducted contained two additional scrubbers, which consisted of boiler plate towers filled with coke, over which the gas passed. Water is sometimes used in these scrubbers depending on the efficiency with which the other apparatus free the gas from tar.

METHOD OF OPERATION.

Under regular working conditions, the generator being filled with a deep bed of ignited anthracite, the fire is blown for about four minutes. The resulting carbon monoxide or producer gas is passed to the carburetter and superheated where it is burned to carbon dioxide. The combustion of the carbon monoxide produces intense heat which is absorbed by the brick checker work of the carburetter. The stack valve is kept open during the blow to allow the products of combustion to escape. By careful regulation of the blast the intensity and distribution of the heat in the various shells can be controlled and adapted to the character of the oil used in carburetting the gas.

When the temperatures in the carburetter and superheater are at the proper point, the blast is shut off and all combustion ceases. The stack valve is then closed and steam is admitted into the generator, being forced through the bed of incandescent coal. The reaction between the steam and heated carbon produces carbon monoxide or non luminous water gas ($\text{H}_2\text{O} + \text{C} = \text{CO} + \text{H}_2$). This gas then enters the carburetter where it meets a spray of heated oil. The passage of the mixed oil and gas over the highly heated checker work, gasifies the oil and thoroughly fixes it with the non-luminous water gas. The result is a thoroughly fixed and permanent illuminating gas which passes on to be scrubbed, condensed and purified.

The period of gas making is continued until the temperature in the apparatus is reduced to the lowest safe point at which disintegration of the steam and oil can be effected. The oil and steam are then shut off, the stack valve opened, and the blowing and heating repeated. During alternate gas making periods the direction of the steam through the generator is reversed.

In the gasification of the oil used in carburetting, many products are formed in addition to the gaseous hydrocarbons. Among these are hydrogen sulphide, naphthalene, benzene and mixtures of heavy hydrocarbons, as tar. The scrubbers and condensers remove the tar and other condensable compounds, while the hydrogen sulphide, a most objectionable impurity, is removed in the purifier. The tar recovered is utilized in various ways. At works where a large quantity is made, it is sold to be further treated for the recovery of valuable carbon compounds. In smaller works it is collected and used as a fuel under the boilers. From the description of the method of operating a water gas plant, it can be seen that there is much loss of energy. In this paper an attempt has been made to study the heat balance of a gas setting and to determine the distribution of heat energy in the various products. The energy is introduced into the machine in the form of coal and oil and partially recovered in the purified gas and tar.

Two tests were made, each on a different machine. The test on one machine continued for forty-eight hours and on the other for forty-eight and three fourth hours or a period of four working days for each machine. During the tests, the weight of coal and oil used was determined and their calorific powers determined. The sum of the heat energy in these forms the debit side of the balance. The amount of heat in the finished gas plus the amount in the tar recovered, forms a partial credit side of the balance. The remainder is loss by radiation and chimney and unburned carbon in the ashes. The ratio between the amount of energy introduced and the amount recovered is the efficiency of the apparatus. The ratio between the energy introduced and that recovered in the purified gas is the efficiency of conversion.

Each determination will be discussed separately, to-

gether with the methods used. The figures for the amounts of materials used were taken from the daily report of the superintendent of the works, as was also the volume of gas manufactured. The calibration of the scales and station gas meter was not checked.

TEST OF MACHINE NO. 1.

The coal used was Pennsylvania anthracite. A sample of the stock heap showed the following proximate analysis:

Moisture	1.15 per cent.
Volatile combustible matter...	4.96 "
Fixed carbon	79.18 "
Ash	14.71 "
Total	100.00 "

Calorific power as determined by the Parr calorimeter 11,556 B. T. U. The amount of coal used during the test was 33.840 pounds.

The oil for carburetting the gas was a crude oil of 0.850 specific gravity. Its calorific power, as determined by the Parr calorimeter was 20,000 B. T. U. per pound. The amount of oil used was 3,920 gallons or 33,438 pounds.

The products to be examined were gas, tar and producer ashes.

The following analyses of the gas were made during the test:

	1	2	3	4	Average
	%	%	%	%	%
Carbon dioxide....	2.4	1.3	1.5	1.5	1.7
Oxygen	0.0	0.0	0.0	0.0	0.0
Illuminants	3.4	4.2	2.7	3.0	3.3
Carbon monoxide..	36.6	36.6	37.2	37.7	37.0
Hydrogen	30.7	28.4	25.1	28.5	28.2
Marsh Gas	18.5	19.4	23.1	21.2	20.6
Nitrogen	8.4	10.4	10.4	8.1	9.2

100.0 100.0 100.0 100.0 100.0

The above analysis was made with the Barnhart apparatus.

The following calorific value of the gas per cubic foot at 60° F. and 760 m.m. barometric pressure was found by means of the Junker calorimeter:

	1	2	3	4	Average
B. T. U. per cubic foot...	616	620	619	619	619

The amount of gas made during the test was 939,800 cubic feet measured at 60° F. and 760 mm. pressure.

The tar condensed from the gas had a heating value of 14,876 B. T. U. The amount of tar was calculated as follows:

Volume of condensate	15,163.36	cubic feet
Percentage of tar in the condensate	1.95	per cent
Volume of tar	295.69	cubic feet
Specific gravity of tar.....	1.023	
Weight of tar.....	18,906.50	pounds
Weight of drip condensate.....	23,937.6	pounds

Percentage of tar in condensate...	2.83	per cent
Specific gravity of tar.....	1.023	
Weight of tar.....	677.43	pounds
The ashes accumulated during the test contained 30.3 per cent of carbon. The weight of ashes was 5,070 pounds and the weight of carbon 1,808.9 pounds.		

THE HEAT BALANCE.

	Weight or Volume of Material	Unit c. p.	B. T. U. Total c. p.
Coal	33,840 pounds	$\times 11.556$	391,055,040
Oil	33,438 pounds	$\times 20,000 =$	668,760,000
Total			1,059,815,040
Gas	939,800 cu. ft.	$\times 619 =$	581,736,200
Tar	19,585 pounds	$\times 14,876 =$	291,346,460
Carbon in Ash	1,800 pounds	$\times 14,600 =$	26,400,400

Total	899,494,060
Loss by radiation and flue.....	160,310,980
Energy regained	873,082,660
Efficiency	$\frac{873082660}{1059815040} \times 100 = 82.37\%$
Efficiency of conversion.....	$\frac{581736200}{1059815040} \times 100 = 54.89\%$

TEST OF MACHINE NO. 2.

All determinations were made in the same manner as described under test of machine No. 1.

A sample of the coal from the stock heap had the following proximate analysis:

Moisture	1.27	per cent
Volatile combustible matter	5.63	per cent
Fixed carbon	80.55	per cent
Ash	12.55	per cent

Total	100.00	per cent
Calorific power	12,012	B. T. U.
Amount of coal used during the test.....	38,880	pounds

The oil for carbureting the gas was a crude oil of 0.849 specific gravity. Its calorific power was 22,435 B. T. U. per pound. The amount of oil used was 3,990 gallons or 33,995.5 pounds.

The following analyses of the gas were made during the test:

	1.	2.	3.	4.	Av.
	%	%	%	%	%
Carbon dioxide....	2.4	2.2	2.5	2.1	2.3
Oxygen	0.0	0.0	0.0	0.0	0.0
Illuminants	4.6	4.2	3.8	5.0	4.4
Carbon monoxide..	33.6	30.6	35.4	38.0	36.6
Hydrogen	27.3	26.6	28.0	26.5	27.1
Marsh gas	23.8	22.6	23.0	22.4	23.2
Nitrogen	8.3	4.8	7.3	6.0	6.3

Total	100.0	100.0	100.0	100.0	100.0
Calorific value in B. T. U. of gas at 60° F., 760 mm. barometric pressure:					

	1.	2.	3.	4.	Av.
	603	606	600	594	601
Gas made was 1,049,900 cubic feet measured at 60° F. and 760 mm. pressure.					
Amount of tar was calculated as follows:					
Volume of condensate in tar well, cubic feet.	19,411.00				
Percentage of tar in condensate, per cent..	1.50				
Volume of tar, cubic feet	291.17				
Specific gravity of tar	1.023				
Weight of tar, pounds.....	18,616.00				
Weight of drip condensate.....	24,545.00				
Percentage of tar in condensate, per cent...	7.26				
Weight of tar, pounds	1,782.00				

The amount of ash which accumulated during the test was 6,290 pounds, containing 20% carbon. The weight of carbon in the ash was 1,258 pounds.

THE HEAT BALANCE.

	Weight or volume of material.	Unit c. p.	B. T. U.
Coal	38,880 pounds	$\times 12,012 =$	467,026,560
Oil	339,955 pounds	$\times 22,435 =$	762,689,043
Total			1,229,715,603
Gas	1,049,900 cubic feet	$\times 601 =$	630,989,900
Tar	20,398 pounds	$\times 14,876 =$	303,440,648
Carbon in ash..	1,258 pounds	$\times 14,600 =$	18,366,800

Total	952,797,348
Loss by radiation and flue.....	276,918,255

Efficiency	$\frac{934430548}{1229715603} \times 100 = 75.98\%$
Efficiency of conversion.....	$\frac{630989900}{1229715603} \times 100 = 51.31\%$

The table following shows very plainly the uniformity of the temperature in the superheater throughout the gas making period. The records were made with the aid of a Le Chatelier pyrometer. The first readings on machine No. 2 were taken about an hour after the morning start and the last were taken about six hours later. Readings were taken each minute of the run. The carbureting oil was shut off at the end of the sixth minute.

DOWN RUN.

Min.	Machine No. 2.				Degrees C. Machine No. 1.			
0	400	405	410	418	420	480	470	543
1	425	435	450	440	450	660	670	650
2	608	625	635	640	655	663	660	678
3	628	640	652	655	660	665	650	683
4	638	640	653	655	665	665	700	690
5	650	640	650	653	662	665	700	688
6	620	635	640	640	660	660	682	675
7	600	620	625	625	640	640	670	665

UP RUN.

Min.	Machine No. 2.				Degrees C. Machine No. 1.			
0	350	400	375	420	420	425	460	543
1	500	620	625	640	650	640	645	660
2	608	625	635	640	655	660	680	650
3	610	630	640	642	655	658	662	680
4	610	625	640	645	658	658	665	685
5	608	620	640	645	655	660	670	685
6	600	610	625	630	640	645	660	678
7	595	605	610	613	620	638	650	670

From the results of the two experiments given, it will be seen that a water gas setting of the Lowe type is an efficient heat-conserving machine. However, much depends on the intelligence and experience used in the

operation of the plant. Owing to the widespread use of carburetted water gas and the enormous quantities of materials used in its production, the problem of more efficient and economical operation is a large one and one worthy of study.

EFFECT OF PRESSURE ON CARBURETTED WATER GAS.

In order to supply more distant consumers, water gas is often compressed and distributed under high pressure. It has been claimed that this compressed gas is lower in illuminating value than the gas supplied without compression. In order to investigate this claim comparative analysis of compressed and low pressure gas were made. The samples were analyzed with special reference to the heavy hydrocarbon content. The samples were taken on the same days from the high and lower pressure lines. The compressed gas was under 40 pounds pressure to the square inch. This pressure is reduced to normal before the gas is used. The table of analyses attached shows that the average hydrocarbon content only varies by one-tenth of one per cent, the compressed gas having the greater amount. That condensation takes place is proved by the fact that a light oil condenses in the high pressure mains and collects in the drips. However, the amount is so small in comparison to the volume of gas from which it is condensed as not to be indicated by ordinary methods of analysis.

ANALYSES TO SHOW EFFECT OF PRESSURE ON COMPOSITION OF GAS.

		Carbon Dioxide.	Oxygen.	Hydro- gen.	Marsh Gas.	Nitrogen.
H. P. Line	1.3	0.5	4.6	30.0	22.1	14.5
L. P. Line	1.9	.00	3.7	31.0	19.7	14.1
H. P. Line	1.6	.00	3.6	39.4	30.5	16.9
L. P. Line	2.0	.00	2.8	40.4	30.0	16.1
H. P. Line	2.0	0.20	4.4	38.8	30.9	16.0
L. P. Line	2.0	.00	4.6	38.6	30.8	15.9
H. P. Line	2.0	0.8	3.8	31.4	29.0	15.2
L. P. Line	1.6	.00	3.8	32.5	29.5	13.1
H. P. Line	1.5	0.70	3.8	39.2	33.1	14.1
L. P. Line	1.8	.00	2.6	39.6	27.4	18.7
H. P. Line	1.6	.00	4.2	37.8	33.1	16.5
L. P. Line	2.0	.00	3.6	37.6	27.5	18.9
H. P. Line	2.1	0.30	3.2	39.2	30.2	16.9
L. P. Line	2.0	.00	4.2	40.8	30.1	15.6
H. P. Line	2.2	0.2	3.8	38.2	34.8	14.2
L. P. Line	1.8	.00	3.7	33.1	30.4	17.3

I am deeply indebted to Mr. E. H. Holzer, superintendent of the Eastern Gas Plant, where the tests in this thesis were made, and to Professor Henry Wysor, under whose direction the work was carried out, for his advice and assistance.

Laboratory of Lafayette College.

M. Ogawa, of the University of Tokio, announces a new element in three somewhat rare minerals—thorine, reinite and molybdenite. In the first-named of these it occurs as small yellow or red crystals, hard enough to scratch glass. These are found to be a double silicate of the new element which has been named Nipporium; its symbol will be Np., and its atomic weight has been ascertained to be probably 100.

WATER SOFTENING OR PURIFICATION AND ITS SAVING.*

By M. MILLER.

Water obtained for boiler use is usually impure, containing incrusting and non-incrusting solids. The continued use of impure or hard water in boilers reduces the life of the flues and fire-boxes, increases the cost of maintenance, cost of coal consumption, and in general reduces the efficiency of boilers.

With the tendency to and demand for high pressure of steam, the question of water for boiler use is becoming more serious as the streams or available water supplies continue to get harder owing to water sheds being more thickly settled and a larger per cent of them being used for agricultural purposes. In former years the water sheds remaining undisturbed for years, the rainfall dissolved and carried into the streams the soluble matter, so, with the protection afforded by the natural soil, the per cent of hardness carried into the streams was small compared to the large amount now carried off the fresh soil after each working.

Mountain streams often contain so little scale-forming matter that the excessive amounts of dissolved oxygen or carbonic acid which they carry in solution may cause corrosion. Such instances are familiar to railroad companies operating in the Allegheny mountains in Pennsylvania.

Peaty waters are found which contain corrosive vegetable acids. Such waters containing free sulphuric acid, and acid iron salts occur in all coal-producing districts, especially in those places where coal is washed preparatory to coke production.

Well waters containing magnesium chloride are corrosive unless they contain an excess of calcium carbonate; the same is also true of waters containing sodium chloride.

The more or less complete removal of scale-forming matter or the neutralization of corrosive substances which occur in boiler feed-water has been carried out by several methods in the United States.

These methods may be classified as follows:

1. MECHANICAL METHODS.

These include feed-water heaters, scum-catchers and blow-off cocks.

2. CHEMICAL METHODS.

(a) Direct Method: The chemicals are placed in the boiler or run into it with the water supply.

(b) Indirect Method: The chemicals are fed into the water on its way to a storage tank, which serves also for the completion of chemical reaction and for sedimentation.

(c) Intermittent Method: The chemical treatment is given alternately to the contents of two or more tanks, allowing enough time for the reaction and sedimentation to take place during periods of quiet. The clarified water is drawn off and pumped to storage tanks or to the places where it is used.

*A paper before the American Water Works Association.

(d) Continuous Method: The chemical treatment is given automatically to the water as it enters the apparatus. The chemical reaction, sedimentation and clarification take place during the progress of the water through the apparatus.

CLASS 1. MECHANICAL METHODS.

Feed-water heaters remove more or less completely from water the carbonate of lime which it contains, but other and more important scale-forming substances are not affected and pass on into the boiler, from which it is impossible to remove them. Sulphate of lime, which forms a very hard scale, is not precipitated in the form of scale until a temperature of 302° F. is obtained, corresponding to about 60 pounds of steam pressure, which heat is not obtained in a feed-water heater.

CLASS 2. CHEMICAL METHODS.

2a. Direct Method.

This practice has been and is very general in the United States, and beneficial results obtained have been in exact relation to the judgment shown in selecting the chemicals and the care shown in carrying out the details of the treatment.

The purifying agents used directly in boilers include.

1. Soda ash.
2. Caustic soda.
3. Phosphate of soda (tri-sodium phosphate).
4. Tannin compounds.
5. Fluoride of soda.
6. Aluminate of soda.

Soda ash has been most widely employed. Used without discrimination, it is rarely beneficial; combined with regular blowing off of the sludge produced by chemical action, it is a measure of great economic importance.

The Soda-Ash System.

Principle: "When waters are treated in the boiler with soda ash, the incrusting solids are changed to carbonates and precipitated as a soft sludge, which is readily blown out, instead of coming down in a crystalline condition and adhering to the boiler."

For Each Grain per Gallon.	Soda Ash per 1,000 Gallons.
Calcium carbonate	0.02
Magnesium carbonate	0.02
Calcium sulphate	0.10
Magnesium sulphate	0.13
Magnesium chloride	0.16

Sludge Removal.—By means of blowoff cocks drawing from several parts of the boiler, sufficient sludge and alkali are removed so that the boiler can be continued in service a much longer time than would be possible otherwise. Some blowing off must be done when boiler is at work, but the greatest efficiency in sludge removal is secured if time for settling is allowed. About 4 per cent of water is blown out with the sludge.

Even in the worst district, the life and mileage of flues and fire-boxes were more than doubled.

Treatment.—Waters containing 25 grains of incrusting solids per gallon required not over 4 pounds of soda ash per 1,000 gallons of water used.

The cost of heating the 4 per cent of water which was blown off was estimated at from 0.4 to 0.8 cent per 1,000 gallons.

Thus the total expense for chemicals and for loss of heat due to blowing off would not exceed 4.8 cents per 1,000 gallons.

Advantages of Direct Soda-Ash Treatment.—Elimination of first cost and interest charges on softening machines or plants.

Limitations of Direct Soda-Ash Treatment.—Boilers must be more frequently washed out, because blowing off does not completely remove sludge.

Foaming occurs frequently, due partly to suspended sludge and partly to the presence of carbonate of soda in variable excess in the water.

Very hard water cannot be treated sufficiently to prevent scale formation without introducing soda ash enough to cause foaming.

Conclusion.—While the use of soda ash is a very useful temporary expedient directed toward scale prevention, all large steam users will eventually discard it in favor of methods which purify feed-water before it reaches the boiler.

2b. Indirect Method.

Treatment of water by the introduction of chemicals into the water as it flows to the storage tank was the first step in the evolution from direct treatment toward complete softening machines. It was designed to avoid the first cost of softening machines by utilizing the existing storage tank for chemical reaction and sedimentation.

Several such plants exist in the United States, and many have existed.

They have no feature to recommend them except low first cost.

2c. Intermittent Method.

The devices described under this heading are intermittent in operation, in that there is a pause of several hours after treatment. This is to give the time considered necessary for chemical reaction and sedimentation.

The general plan of operation is as follows:

Two or more tanks are provided, the aggregate capacity of which is usually four times the hourly output expected.

These may be of either wood or iron construction, and may be placed on ground level or elevated on trestlework, according to whether repumping of softened water is to be allowed for or avoided.

The tanks are filled alternately to a certain level with hard water. In some plants the milk of lime is added during the filling, and the agitator is run at the same time. In most of the plants the practice of dissolving the soda ash in the milk of lime and adding both together when the tank is filled is the one followed.

Agitation continues for 15 to 20 minutes, followed by a period of perfect rest, usually varying from one to two hours.

At the end of this time the softened water is drawn off in a proper manner to avoid the introduction of the precipitated solids of storage tanks from which it is repumped to a higher elevation if necessary, or drawn direct from the treating tank.

2d. Continuous Method.

The type of machine now referred to is the one which is so designed that the flow of water to the plant operates all necessary mechanism (stirrers, etc.).

The feed of chemicals is regulated by proportioning devices. Proper mixing of chemicals with hard water takes place automatically as the water passes through the machine; the chemical reaction is complete and sedimentation takes place. A filter at the top of the machine gives final clarification, and the softened water is discharged without repumping into the storage tank.

Great advancement has been made in results obtained by use of this method and the simplicity of the machine used.

THE ECONOMIC RESULTS OF WATER SOFTENING.

The considerations which lead to the taking up of water softening by steam users may be grouped as follows:

First. Loss of services of boilers, due to impossibility of satisfactory continuous operation with hard water.

Second. Possibility of substantial savings in fuel and repair bills and the checking of rapid deterioration of boilers.

The direct cost of water for boiler use is often but a small part of the expense in connection therewith.

The direct cost involves:

1. Cost of supply and pumping plant.
2. Cost of pumping.

The indirect cost involves expense due to:

1. Corrosion of boiler-tubes and fire-box by waters containing acids.
2. Incrusting due to presence of scale-forming material.
3. Interference with operation and incidental danger due to engine failures from these causes and from boilers foaming.

The cost of water softening undertaken for the first reason is not always a matter of prime importance. It must be reasonable, of course, but results are the main thing. In most cases, however, water softening stands or falls by the relation of what it costs to what it accomplishes.

The charges against a water-softening installation are:

- Interest on cost of plant.
- Depreciation.
- Chemicals for softening.
- Attendance.
- Power for operation (and repumping).
- The credit items for a softener are:
- Fuel saving.

Repair saving.

Depreciation saving.

Increased service obtainable from steam generators.

Cost of Softening Plants.

The best softening plants cost from \$4 to \$5 per h. p. for installation up to 1,000 h. p.; for 1,000 to 2,000 h. p. the cost is \$4 to \$3 per h. p. From 2,000 to 5,000 h. p. the cost is \$3 to \$2 per h. p. From 5,000 to 15,000 h. p. the cost is \$2 to \$1.20 per h. p.

Depreciation.

The above figures refer to steel construction. Plants for which wooden tanks are used are sometimes offered at as high rates, but the depreciation of wooden tanks under service conditions is much greater, besides other disadvantages. If steel tanks are reasonably well cared for, 5 per cent is more than enough to allow for their depreciation.

Cost of Chemicals.

The quantity of chemicals required for softening varies directly with the character of the water treated. The prices of lime and soda ash do not vary greatly in different sections of the country. There is, however, great choice in commercial lime, much of the building lime being so high in magnesia as to make it unfit or uneconomical to use. From 90 to 95 per cent lime can be had and should be insisted upon.

In my experience I have found it more economical to use hydrated lime, thus avoiding the objectionable features associated with lump lime, which are the grit and unburned limestone and the loss due to air slacking of the lime while in transit and while stored at the plant.

The cheapest waters to soften are those the hardness of which is due to carbonates of lime and magnesia only. Such waters require simply lime-water treatment. It costs only 0.2 cent per 1,000 gal. to remove 1.42 lb. of carbonate of lime (equivalent to 10 gr. per gal.), and only 0.48 cent to remove the same quantity of carbonate of magnesia.

The amounts are sufficient to give a great deal of trouble in heaters and boilers.

The removal of sulphates and other soluble compounds of lime and magnesia from water requires the use of soda ash. It costs 1.20 cents per 1,000 gal. to remove sulphate of lime equivalent to 10 gr. per U. S. gal. The same amount of sulphate of magnesia requires 1.36 lb. of soda ash, which costs 1.36 cents per 1,000 gal.

Attendance.

The cost of attendance at softening plants varies greatly, but is never more than that of the time of one man (or boy). It is often much less. The most common arrangement is for the engineer or pumper to look after the softening plant.

With the best type of plants two or three hours per day are all that are required for attendance unless the installation is very large.

Chemical tests for control of the softening plant can be carried out by persons of average intelligence.

The most satisfactory plants are those where the power for mixing and pumping the chemicals is gotten from the flow of water to the softening plant, so arranged that the flow of the water starts all stirrers, or other mechanisms, and the filter, as it becomes dirty, changes the direction of the flow of water, automatically changing the valves allowing the treated and filtered water to be drawn from the storage tank through the filter, washing the sand and discharging the sludge through sludge pipes into sewers. The tilting bucket can be so arranged as to give the desired amount of water to wash the filter when it will, by counter weights, be carried back to its normal position.

The advantage of this plant is that it is automatic, and requires less attention on the part of the operator. The plant was designed for railroad water supply, but what holds good for railroad water supply will be equal for any steam boiler.

The best plants have all stirrers or other mechanism actuated by water power. The flow of water to be softened starts everything, and the water is softened at a sufficient elevation to run by gravity to the place where it is to be used.

FUEL SAVING.

The earliest recorded researches on the subject of loss of heat caused by boiler incrustation are those of John Graham, conducted in 1850 to 1857, and published in *Memoirs of the Literary and Philosophic Society of Manchester* in 1860. He says: "A scale of sulphate of lime 1/16 in. thick reduced the efficiency 14.7 per cent."

Dr. J. C. Rogers states that a scale 1/16 in. thick makes 15 per cent more fuel necessary than with clean heating surfaces.

Rankin states that it is estimated that 1/16 in. of scale requires the use of 16 per cent more fuel.

Reuben Wells ran two engines for several months with heating surfaces covered with scale, and an equal length of time later with clean heating surfaces, and found a fuel saving of 17.5 per cent. Details of scale thickness or density are not given.

These records would seem to be sufficiently convincing, and yet they are sometimes questioned, as if they were theoretical calculations instead of actual results.

FUEL SAVING ON RAILROADS.

Three railroads, the Union Pacific Ry., Chicago & Northwestern and the Pittsburg & Lake Erie R. R. Co., have installed a large enough number of softening plants to warrant the expectation of definite results showing fuel economy, etc.

Of these, only the Union Pacific Ry. has given out preliminary results. They report 7½ per cent increase in gross ton-miles per pound of coal. This is believed to represent the effect on boiler conditions of 10 softening plants on the Nebraska Division, and is really not a comparison between steam raising with clean tubes and the same with scaled ones.

Better results are sure to be obtained. Even as they

are, they lend additional evidence to an already certain matter.

BOILER REPAIR SAVING.

Estimates.—For C., B. & Q. Ry. Co. engines operating in Illinois and the hard-water districts of the middle west, Wickhorst estimates that boiler repairs cost \$1,200 per locomotive per year, and that softening should reduce this at least 25 per cent.

The engineering department of the P. L. E. R. R. Co., having moderately hard waters to deal with, estimate that with water softening a saving of at least \$100 per locomotive per year will be realized from boiler repair saving.

Actual Results. Returns from railroads, etc., having water softeners in operation give results which exceed the above estimates.

The C. & St. P. Ry. Co. reported in 1899 that Smith's soda-ash treatment of boiler water had made possible an annual saving of \$75,000 in boilermakers' pay roll.

The Union Pacific Ry. Co. report as a result of water softening 34 per cent decrease in boiler repairs per engine-mile.

The C. & N. W. Ry. Co. report 40 per cent decrease in boilermakers' force required for repairs on their Iowa Division during the last six months of 1903 as compared with the corresponding period in 1902.

On the Missouri Division of the St. Louis, Iron Mountain & Southern Ry. Co. in 1906 three water-softening plants were installed at an actual cost of \$12,500, which made an actual saving of \$12,245 in boilermakers' salaries, handling an increased tonnage of 15 per cent, reducing engine failures 97 per cent, with a decrease in number of engines.

On the Colorado Division of the Missouri Pacific Ry. Co. the installation of four treating plants out of 14 water stations decreased the cost of boilermakers' salaries in one year \$8,800, handling an increased business of 14 per cent with 5 per cent less engines.

These records show that in all cases where water contains over 10 gr. of scale-forming ingredients, by treating the water the life of flues and fire-boxes is increased 100 per cent. With 20 gr. the increased life of flues and fire-boxes with treated water is 200 per cent.

At the Missouri Pacific shops at Kansas City, Mo., we have three boilers in use, one 150 h. p., one 80 h. p. and one 45 h. p. Previous to 1905 flues had to be changed in these boilers every six months. In 1906 we put into use a water softening plant and renewed the flues in all of the boilers, and they have been in use ever since and show no signs of leaking at the present time, after three years' use of softened water.

During the month of December, 1905, we pumped 8,220,000 gallons of water; and in the month of December, 1908, 12,460,000 gallons of water, with a saving of 20 per cent in fuel over that used in December, 1905.

About the same ratio of saving is shown on switch engines working in this yard, where they get nothing

but softened water. Following is the mineral analysis of the water at this point:

	Gr.
Carbonate of lime.....	16.79
Carbonate of magnesia.....	3.42
Sulphate of lime.....	0.75
Sulphate of magnesia.....	2.06
Oxides of iron and aluminum.....	0.12
Silica	1.91
Alkali chlorides	0.88
Alkali sulphates	0.29
Organic matter, etc.....	0.82
Total solids	27.04

Total incrusting solids 25.05 grains per U. S. gal., or 3.58 lb. per 1,000 gal. Total non-incrusting solids 1.99 gr. per U. S. gal., or 0.28 lb. per 1,000 gal.

Depreciation of Boiler Plant.

It is difficult to put into dollars and cents exactly what water softening means in prolonging the life of boilers. The wear and tear on boilers using softened water would certainly average 75 per cent less than with untreated water.

The Union Pacific Ry. Co. now finds a set of flues lasting two and one-half years, where formerly six months to a year was the limit.

Washing Out Boilers.

A marked decrease in this item is noticed by users of water-softening plants.

While the accumulation of soda salts necessitates water changing by blowing off quite frequently, yet complete washing out for the removal of sludge and scale is much less frequently required than formerly.

Increased Service from Locomotives.

When locomotives are in the roundhouse or shop, their owners are losing; the same would be true of any commercial plant where steam boilers are used.

1. Interest and depreciation.
2. Their entire earning capacity.

Instances are known in industrial plants where water softening has made so much more boiler horsepower constantly available that contemplated extensions of plants have become unnecessary.

It is already evident that the financial benefits derived from the adoption of water softening far outweigh the expense.

CHEMICAL CONTROL OF SOFTENING PLANTS.

Skilled supervision is not necessary after the operator has learned to make tests for hardness, alkalinity and excess of lime.

Hardness is determined by the soap test, alkalinity or acidity by titration, with standard acid or alkali. The silver nitrate test is used for detecting excess of lime.

By use of tables the operator is able to change the treatment to suit the conditions shown by his tests.

Prof. L. P. Breckinridge, of the University of Illinois, as a result of careful tests of the effect of scale on rate of evaporation in a locomotive boiler, showed the loss due to scale from 1/32 to 3/64 inch in thickness to be 9.55 per cent as compared with the results from the same engine after cleaning the boiler and putting in new flues.

It is assumed that the loss is indirectly in proportion to the thickness of the scale.

Assuming 1/32 in. formation in 6 months, which would be produced by a very fair quality of water, 10 grains of incrusting solids and a loss of 9 per cent in evaporation due to scale of this thickness, we have

Months	boiler operated without cleaning.	Losses of evaporative efficiency at end of period.	Per cent.	Average loss of evaporative efficiency for period.	Per cent.
	2	3	1.5		
	4	6	3.0		
	6	9	4.5		
	8	12	6.0		
	10	15	7.5		
	12	18	9.0		

Loss of evaporative efficiency means increased coal consumption. Assuming the normal consumption of an engine per year as 3,000 tons at \$2 per ton, equals \$6,000 and 5,000,000 gallons as the normal water evaporation, gives.

Months boiler operated without cleaning.	Average loss of evaporative efficiency for period.	Per ct.	Cost of increased coal consumption per engine per year.	Cost of increased coal consumption per 1000 gal. of water evaporated.
2	1.5		\$ 90.00	1.8 cts.
4	3.0		180.00	3.6 cts.
6	4.5		270.00	5.4 cts.
8	6.0		360.00	7.2 cts.
10	7.5		450.00	9.0 cts.
12	9.0		540.00	10.8 cts.

The cost of washing locomotive boilers may be assumed roughly as from 60 cents to \$1.20 per boiler washed, averaging say \$1, and the saving due to reducing the frequency of washing from each 20 days to each six months would be about \$20 per year, or 0.4 cent per 1,000 gallons of water used.

The cost of removing, cleaning and replacing boiler tubes per set can be placed at \$110. The difference in life with good and with bad water may be taken roughly at 24 months for good water and 6 months for poor water used. While these figures are mostly from a railroad saving, the same would hold good in the boiler-room.

THE MANUFACTURE OF LIQUID ILLUMINATING GAS IN SWITZERLAND.

In response to instructions, Consul-General R. E. Mansfield of Zurich has investigated and prepared the following account of the manufacture of liquid illuminating gas in Switzerland. This gas is popularly known as "Blau gas" because it was invented by Herr Blau. A sample of it was recently shown by one of the members at a meeting of the New York section of the Society of Chemical Industry.

Chemists who are interested in the process may obtain the loan of pamphlets, charts and blueprints showing the factory building, plans and equipment for liquid gas manufacture from the Bureau of Manufacturers, Washington, D. C.

While the principle of producing liquid gas was discovered nearly a century ago, and such chemists as Faraday (1823), Andrews (1861), and scientific investigators like Cailletet, of Paris, and Pictet, of Geneva (1877), left valuable records relating to the subject, they succeeded in establishing only a theory that "all gases pass into a liquid condition, provided that they are submitted to a sufficiently low temperature and to a sufficiently high pressure." To make a practical application of this theory, and work out a process by which liquid gas could be utilized for general purposes and produced at a cost that would make it a commodity of commercial value, has occupied the attention of various inventors in recent years.

The constantly increasing scarcity of natural fuels, and the consequent advance in the cost have increased proportionately the interest in and the importance of substitute or artificial fuels or substances for producing light and heat.

The first plant for the manufacture of liquid gas as a commercial commodity was established in Augsburg, Bavaria, in 1904, under a process invented by Herr Blau. Considerable success has attended the enterprise, a great many installations for heating and lighting having been made by the company in Germany, and some of the German railways have adopted it as a means of lighting passenger coaches.

In 1907 a stock company for the manufacture of liquid gas was organized in Zurich, under the name of the "Swiss Liquid Gas Company" (Schweizer Fluessig-Gas-Fabrik, L. Wolf, A. G.), and a factory, with a capacity of 480 pounds of liquid gas a day, was established at Bassersdorf, near Zurich. The apparatus for the purpose of transforming crude oil into liquid gas, with which the factory is equipped, is the invention of L. Wolf, a resident of the village of Bassersdorf. The product is described by the company as "a transportable liquid, which is simply evaporated as used, and can be used for lighting, heating, cooking, soldering, and welding purposes."

FACTORY EQUIPMENT—BY-PRODUCTS.

The factory building is a plain one-story stone structure, 40 by 72 feet, and was built at a cost of \$24,000. It is equipped with one 12-horsepower explosion gas

engine, which furnishes the motive power to drive the compressors working at high speed. The engine is supplied with gas produced in the process of reducing the crude oil to liquid gas. The furnaces in which the retorts are heated are also partially supplied from the same source, about one-half of the fuel consumed being surplus or exhaust gas. The application of this by-product reduces the cost of fuel for operating the plant to the minimum. In addition to the residue of gas, a considerable residuum of tar is secured in the process. From the tar may be extracted lubricating oils, benzole, cresote, and materials suitable for street and road dressing as a dust preventive.

The material from which the liquid oil is produced in the Bassersdorf factory is the residue or refuse of crude oil after various ingredients such as benzene, vaseline, etc., have been extracted. It is imported from Austria. At the factory the crude oil is transferred from a reservoir into the retorts by an automatic process. The cost of the oil used in the Swiss company's factory is about 7 cents per gallon.

After passing through the process of heating, condensation, and cooling, and the various carbonizing and other substances have been separated from it, the liquid gas is placed in steel tubes of various sizes holding 20, 40, 60 and 80 pounds each, in which form it is ready for use. The tubes containing the material are accepted by the railways and other carrying companies without restrictions or special provisions, as the gas is nonpoisonous and is three times less explosive than ordinary gas. The liquid gas is utilized by attaching one of the tubes to the special apparatus manufactured by the company, which contains a regulator, gage, etc.

INSTALLATIONS AND USEFULNESS.

The Bassersdorf concern, which has passed beyond the experimental stage, now has over 100 installations in different towns and cities in Switzerland, all of which are declared to be entirely satisfactory to the purchasers. In a descriptive circular regarding the production of liquid gas, its uses, etc., the company says:

The liquid gas is obtained by the dry distillation of raw petroleum and of by-products of the lignite and oil industries. The raw materials are decomposed in retorts by the action of a high temperature; the vapors and gases produced then pass through the tar separators and the cleaner, losing here the easily condensable gases (tar, benzene, etc.), as well as any deleterious and malodorous by-products that may be present. By means of Wolf's patent apparatus, and the use of cold and pressure, a separation of the difficultly liquefiable gases, such as hydrogen, methane, etc., from the more easily liquefiable ethane, propane, pentane, etc., is obtained. These are then liquefied, carbureted, and filled into steel transport cylinders provided with a valve and sold as "liquid gas." It is easily transportable and utilizable and has a high illuminating and heating power. The prime cost is not greater than that of other kinds of gas produced in

small plants. The installation costs are low and the manipulation is simple and without danger. The gases not liquefied are used in the working of the factory.

It is claimed for the liquid gas that it is nonpoisonous, and its explosiveness is about three times less than coal gas.

Specific gravity of the liquid gas (water:1)	
(about)	0.568
Specific gravity of gaseous liquid air (air:1)	
(about)	1.021
1 liter gaseous liquid gas weighs (at 0° and 760 millimeters pressure) (grams).....	1.3201
1 cubic meter (35.314 cubic feet) liquid gas weighs under like conditions (kilos).....	1.3201
Maximum heating value per cubic meter of gas (at 0° and 760 millimeters pressure (thermal units)	16.046
Minimum heating value per cubic meter of gas (at 0° and 760 millimeters pressure (thermal units)	15.137
The company's descriptive circular says:	

The liquid-gas installation consists of the transportable cylinder containing the liquid gas, of a gas tank fitted with a pressure gauge and adjustable safety valve; also of a regulator for adjusting the pressure of the gas.

HEATING, LIGHTING AND WELDING.

The advantages and conveniences offered by liquid gas present for it a wide field of usefulness. Among the various uses to which it may be applied are the heating and lighting of residences, public buildings, hotels, and manufacturing, and street lighting and cooking purposes; also chemical and technical laboratories, soldering and welding. If mixed with oxygen it produces a heat so intense that an ordinary bar of iron 1 inch in diameter can be cut in two almost instantly by placing it in the flame of a liquid-gas burner. This concentrated heating power makes it available, and especially desirable in the smelting and forging of iron and steel.

Concerning its application as a means of welding, etc., the company claims for liquid gas that—

Any required grade of heat favorable for the metal to be welded can be produced by simply regulating the pressure and quantity of gas. The metal melts and flows together without oxidizing; no pressing, no hammering, is necessary, and the metal does not turn brittle. With a medium heating value of 15,600 thermal units, liquid gas affords the cheapest and best method for the welding of metals.

The success of the Bassersdorf factory has demonstrated the fact that liquid gas can be manufactured and sold at a profit in competition with coal gas and electricity, as nearly every town and village in Switzerland is supplied with artificial-gas works and an electric-lighting plant. Yet within a short space of time the company has placed over 100 liquid-gas installations, and the demand for its product keeps the plant running full capacity day and night. When it is

understood that the factory was built more as an experiment and for the purpose of demonstrating the practicability of manufacturing liquid gas as a material for heating and lighting than as a commercial enterprise, and the fact that all the material used is imported, which greatly increases the cost of production, it can be readily seen that greater profits might be obtained from the manufacture in the United States, where raw material, such as waste from rock-oil refineries or other kind of bituminous oils, are plentiful and comparatively cheap.

FACTORY BEING BUILT IN BOSTON.

The Zurich company, which possesses international patents, has disposed of the rights to manufacture under its process in France, and a plant with a capacity of 1,056 pounds of liquid per day is in course of construction in Paris and will soon be ready to begin operations. A factory equipped with the Wolf patent apparatus is being built in Boston.

The Swiss plant turns out 480 pounds of liquid gas per day, besides a considerable quantity of tar. Only four men are employed in the work of operating the factory, which runs day and night. No special mechanical skill is required in the work, which reduces the cost of labor to the minimum. For the construction and installation of plants for lighting, heating, cooking, industrial and laboratory purposes about 20 mechanics are employed. These men also act as soliciting and selling agents and promoters of the company's interests in towns where there are no coal-gas plants.

The finished product is put up in different sized metal tubes, holding 20, 40, and 80 pounds each, the market price being 15 cents per pound, or \$3 for a tube containing 20 pounds. This gives the daily output of the factory, amounting to 480 pounds, a total value of \$72.

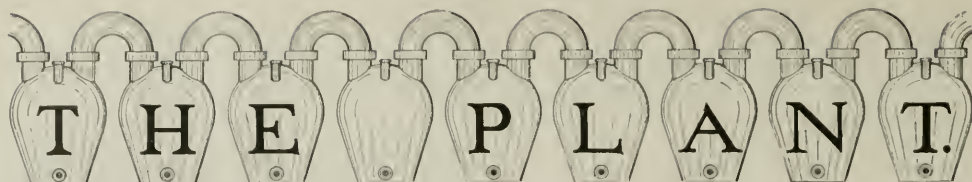
ESTIMATED COST OF PRODUCTION AND PROFITS.

The Zurich company estimates the cost of production, profit, etc., on a plant with a capacity of 44 pounds of liquid gas per hour, as follows:

Forty-four pounds per hour, 1,056 a day, for 300 days in the year, 316,800 pounds; market value, 15 cents per pound.....	\$47,520.00
Cost of production: Raw material—gas oil, 2,240 pounds daily, or 672,000 pounds for the year, at a cost of 0.724 of 1 cent per pound	\$4,825.28
Carbureting: 422 pounds daily, 126,600 pounds for the year, at 38.6 cents per pound	4,876.66
Fuel: 1,815 pounds daily, 544,500 pounds per year, at 3 cents per pound	1,633.50
Wages and salaries:	
Four workmen, at \$1.16 per day each, for 300 days	1,392.00
One foreman	695.00
One clerk	465.00
Total cost per year.....	13,927.44

Profits for 1 year.....\$33,592.56

Estimated cost of building a liquid-gas factory with a capacity for producing 1,056 pounds per day, \$5,000. Cost of machinery and apparatus for operating the plant, \$40,000.



THE MECHANICAL PREPARATION OF SOLIDS FOR CHEMICAL TREATMENT—GRINDING.*

Written for The Chemical Engineer.

(Continued from September issue.)

The edge runner (Fig. 20) is made in two different types and under the names "edge runner mills," "Chaser mills," "Chillean Mill," "Dry Pan" and "Wet Pan," according as used for wet or dry grinding. It consists of a pan in which revolve one or more rollers. Either the pan itself or the rollers may be driven. In the first form, the pan is driven and the rollers are dragged around by the evolution of the former. In another type, the pan remains stationary and the rollers are driven around. This latter type of mill, however, is much less employed than the former and usually only in cases where the nature of the material would allow slipping of the rollers as in grinding paints and colors in oil. Both the pan and runners are usually made of cast iron. The mill grinds by the weight of the rolls acting on the particles to be ground. Steel scrapers or plows keep the material to be ground under the rolls as the pan revolves. Where the material is to be ground to a definite size, the pan bottom is often fitted with steel grids, letting the crushed particles through, and

hard substance such as armor plate, chilled steel, quartz or trap-rock and revolves at a speed of from 25 to 27 revolutions per minute. The material is fed in through a hollow shaft and leaves either in the same manner at

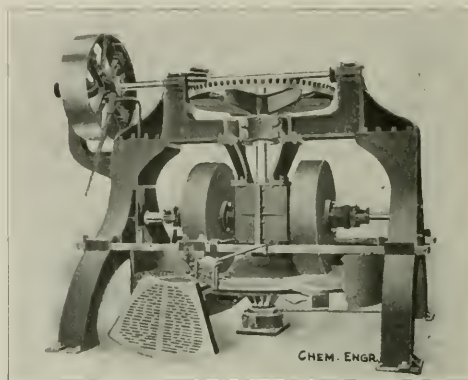


Fig. 20—Edge Runner Mill (Power & Mining Machinery Co., Cudahy, Wis.).

the opposite end or else through a grating at the perimeter of the end. In the Smidth tube mill the latter

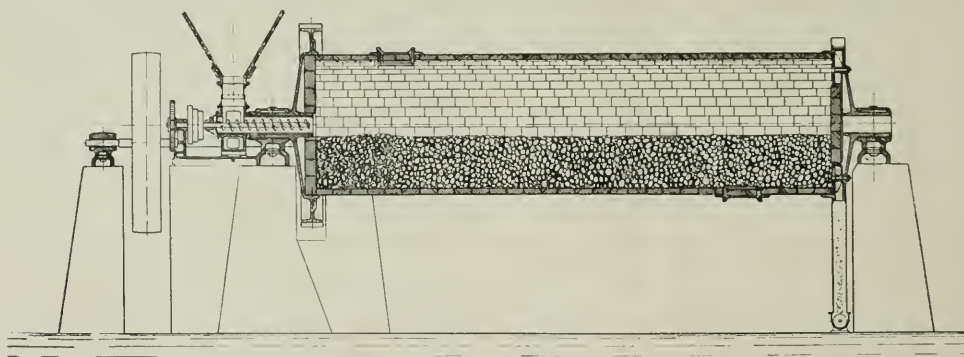


Fig. 21—Tube Mill (F. L. Smidth & Co., New York).

the coarser material is scraped back under the rollers by means of scrapers. These mills are sometimes made in very large size for use in the cyanide treatment of gold ores. A 5 ft. mill requires about 12-15 H.P.

The tube mill, Fig. 21, consists of a cylinder, 20 to 22 feet long, and from 60 to 66 inches in diameter, filled with flint balls. This cylinder is lined with some

course is pursued, and the Gates and Krupp mills the former plan is followed. In the Abbe mill the shell is revolved upon tires and rollers, and the material is fed in by means of a spiral. In the Hardinge type of mill the shell is cone shaped. The flint pebbles are generally imported from Europe and the wear depends upon the hardness of the material to be ground. Steel balls are sometimes used in tube mills for grinding wet materials. The material is usually fed into the tube mill by means of a screw conveyor operated by a step-

*This is the fourth series of articles upon the Elements of Chemical Engineering. Former articles, treated of the Materials of Construction, Storage of Materials, Conveying Materials, and Weighing and Measuring Solids, Liquids and Gases. The next series will be upon drying.

pulley which permits the cutting down of the feed, or by a roller feed with movable gate, or by a shaker feed, any of which can be adjusted to regulate the amount of material going into the mill. A tube mill, $5\frac{1}{2} \times 20$ feet, usually requires 80 horse-power to run and about double that quantity momentarily in starting. The amount ground will of course depend upon the hardness of the material.

Of the mills in which the separator and pulverizing unit are on the same base, the Fuller-Lehigh, Huntington and Griffin mills are best known.

The Fuller-Lehigh Mill (Lehigh Car, Wheel &

die, by means of air currents induced by fans *g*. The material is pulverized by the rolling of the balls against the die, the pressure of each ball against the latter being over 2,700 lbs., the grinding action being similar

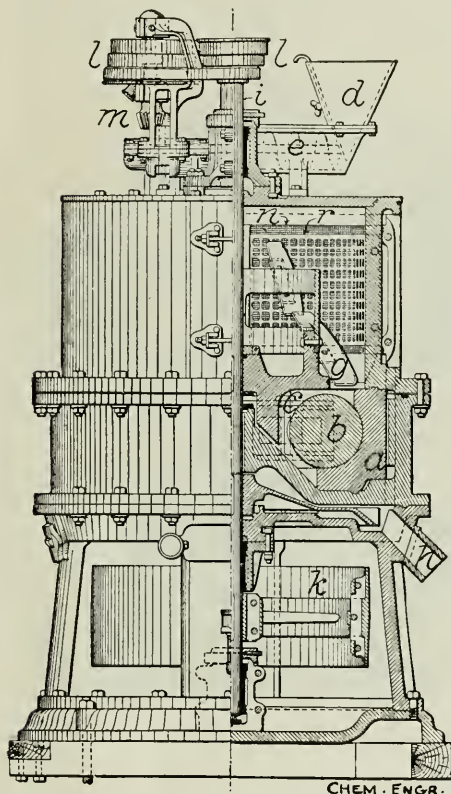


Fig. 22—Fuller-Lehigh Pulverizer (Lehigh Car, Wheel & Axle Works, Catasauqua, Pa.).

Axle Works, Catasauqua, Pa.) consists (see Fig. 22) of a horizontal ring or die *a*, against which revolve four balls *b*. The balls are propelled by means of a pusher *c*. The balls, pusher and balls are made of chilled iron, and the latter weigh 260 lbs. each and are 12 inches in diameter. They revolve at a speed of about 155 revolutions per minute and hence press against the die with enormous (centrifugal) force. The material to be ground is fed into the hopper *d* and from this into the mill, falls down into the pan of the mill, situated below the die, and is drawn up from this, in between the rapidly revolving balls and the stationary

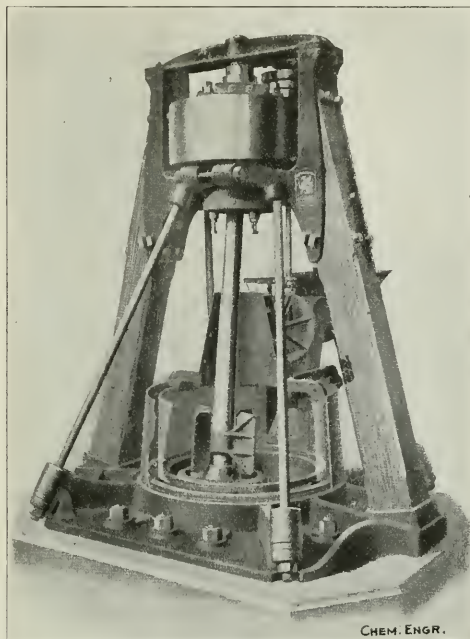


Fig. 23—Griffin Mill (Bradley Pulverizer Co., Boston, Mass.).

to that of a mortar and pestle. The fully pulverized material is sucked upwards by the fans, *g*, and blown through the screens *r* and *n*, falling down between this screen and the outer casing and being discharged from the mill at *h*. The coarse particles being too large and

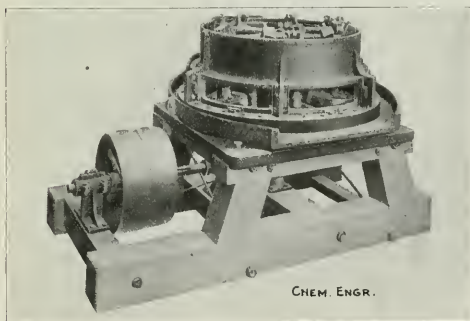


Fig. 24—Huntington Mill (Allis-Chalmers Co., Milwaukee, Wis.).

too heavy to be carried upward and through the screen by the fans, fall back into the trough to be again thrown up between the die and the balls, etc. The shaft extends through the top of the mill and actuates the

feeding device. The feed to the mill and consequently the fineness of the products may be controlled in two ways, either by a slide on the hopper or by means of the stepped pulleys *l, l*, connected to the screw conveyor or by gearing, *m*. The mill is provided with two screens; one, the inner, *r*, of one inch mesh and made

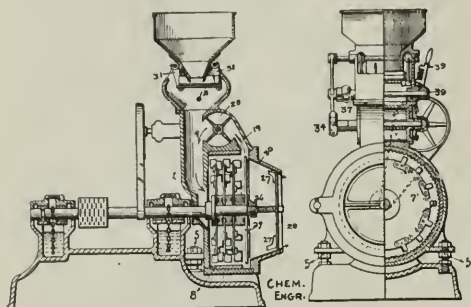


Fig. 25—Limited Pulverizer (Schutz & O'Neill, Brooklyn, N. Y.).

of very heavy wire to protect the outer one, *n*. The outer screen does not really screen but merely controls the draft of air, and hence the fineness, since the greater the velocity the greater the carrying power of the air and hence the coarser the product. The mills are very economical of both power and repairs. They cost \$3,000 and require but little additional to install, as the foundations are small. The mill is also made in a smaller size (33 inch). A 42-inch mill requires from 60 to 70 H.P.

The Griffin Mill, shown in Fig. 23, is somewhat similar to the Fuller-Lehigh mill in principle. It consists of a steel die against which a roll, also of steel, is made to revolve, and it is between these two that the mate-

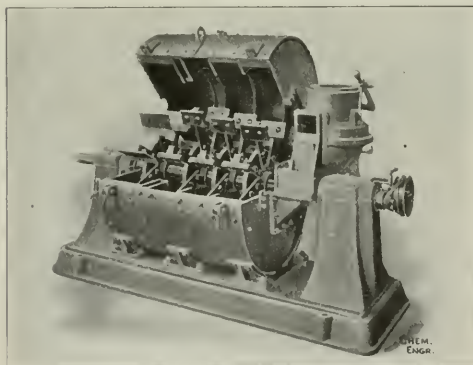


Fig. 26—Aero Pulverizer (The Aero Pulverizer Co., New York).

rial is ground. The roll is suspended by a shaft from a spider and actuated by a pulley to which the shaft is attached by a universal joint. The fully-ground material is sucked up and forced through the screens by fans on the shaft, and the coarse particles, falling back into the pan of the mill, are thrown up between the

roll and die by means of plows attached to the roll. The finished product passes through the screens and downward between these and the outer casing, through openings in the base, to the screw conveyors. Each mill takes from twenty-five to thirty horsepower. These mills are partly open at the top and hence are very dusty.

The three roll Griffin is a new mill recently brought out by the manufacturers of the Griffin mill, which is somewhat similar in principle to the single roll Griffin mill. As its name implies it has three rolls in place of one. It is provided with screens, fans and ploughs which perform the same work as in the old style Griffin mill. These mills have been given a thorough trial on

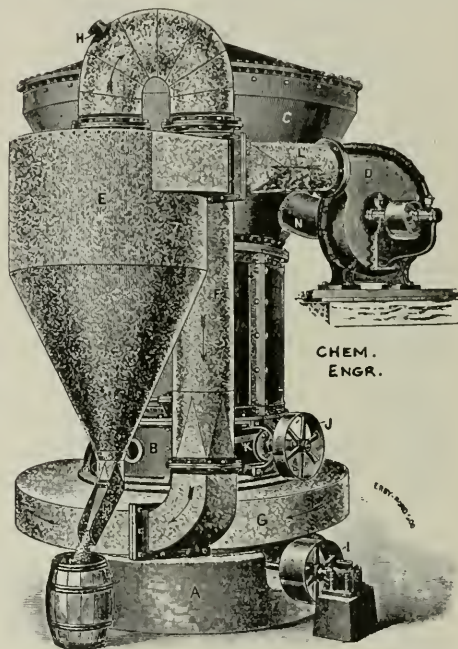


Fig. 27—Raymond Roller Mill (Raymond Bros. Impact Pulverizer Co., Chicago).

grinding raw material, but so far have been only used experimentally for grinding clinker. One of the newer mills in the Lehigh district has its entire raw side equipped with these mills and reports from this plant credit them with doing remarkably well. The three roll mill requires about 40 horsepower to run.

The Huntington mill is another mill of the impact or percussion type and is somewhat similar to the three roll Griffin mill in construction, it is much used in the metallurgical industry.

The Huntington mill, Fig. 24, has shells freely suspended on spindles from a revolving spider. The revolution causes the shells to swing out and crush against the edge of the die ring. The machine generally is a great consumer of repairs.

A number of mills of the "Max" mill type have been

used for fine pulverizers by the attachment of a separating system of some form or other. Among the best known of these are the "Aero Pulverizer," the "Stroud Pulverizer" and the "Limited Pulverizer." The latter is manufactured by Schutz & O'Neil. Fig. 25 shows the pulverizer which is attached to the dust collector or separator not shown. It consists of a movable grinding shell, 8, against which the beaters, 7, throw and pulverize the material. This shell when worn may be replaced. The feed of the mill is regulated by slides 31 and 31. The material is prevented from flying out of the grinding chamber by means of the plate 29. The fineness of the product is regulated by means of the fans 27 and 27, which may be set to regulate the draft and consequently the fineness. In action, the beaters throw the material against the shell and when sufficiently fine the fans suck it out into the dust collector. This mill is used extensively for pulverizing drugs, dry colors, chemical crystals, sugar, etc. One advantage of mills of this type is that they are kept cool by the air

ring or die. The air enters the mill through a series of openings located around the pulverizer chamber and directly under the die and rollers. The material which has been reduced to the required degree of fineness is carried away by air currents into a separator which is located to the side of the mill. This separator consists merely of a large cone-shaped chamber in which the velocity of the air, of course, decreases and consequently the particles fall from suspension. The air currents in this mill are induced by a blower which is entirely separate from the mill. The size separator employed depends to some extent upon the fineness to which the material is to be ground. These mills have been used for grinding quite a variety of substances, such as barytes, bauxite, borax, carborundum, cryolite, graph-

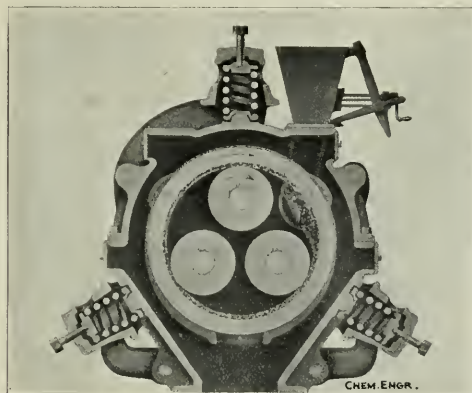


Fig. 28—The Maxecon or Kent Mill (Kent Mill Co., New York).

currents and hence may be used for materials which would melt or be spoiled by a machine in which heat was generated by friction, due to rubbing.

The Aero Pulverizer is shown in Fig. 26. It consists of three communicating chambers, each slightly larger in diameter than the preceding one, in which revolve paddles on arms, whose length corresponds with the increased diameter of the chambers. A fourth chamber contains a fan which is used to draw the more finely pulverized material from one chamber to the next, and finally to deliver it to a settling chamber or dust collector. The air required for pulverizing purposes is admitted with the coal through inlets, in the feed device.

The Raymond roller mill is shown in Fig. 27. The pulverizing unit of this is somewhat similar to that of the three roll Griffin mill. There are four rolls which swing outward by centrifugal force against a ring die. A plow is located ahead of each roll which throws a stream of material between the face of the roll and the

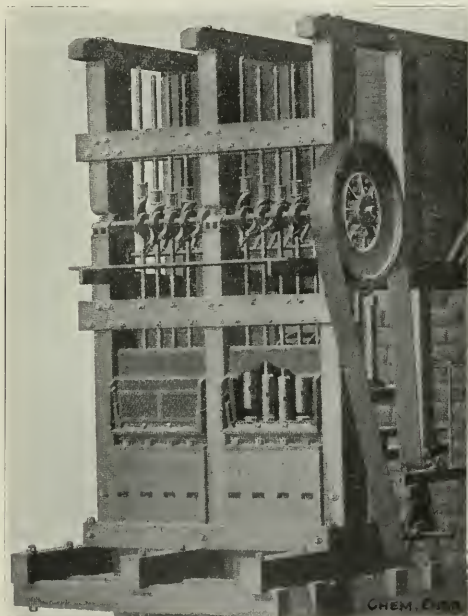


Fig. 29—Battery of Stamps (Allis-Chalmers Co., Milwaukee, Wis.).

ite, gypsum, sulphate of iron, magnesite, dry colors, red lead, bi-carbonate of soda, etc.

The Kent mill is shown in Fig. 28. This mill requires an outside separator. It consists of a vertical revolving ring having three grinding rolls which are mounted on horizontal shafts and which press against the inner surface of the ring. The material to be ground is fed on the inner surface of the ring and is ground between this and the rolls. The inner surface of the ring is slightly concave and the material is kept in the center of this and between the ring and rolls by centrifugal force.

Stamp mills are extensively used in metallurgy, but find almost no application in the chemical industry. Nevertheless, it may not be amiss to describe them in this article. The stamp mill is nothing more than a

mechanically operated mortar and pestle. For mining purposes they are generally erected in batteries of five or ten. Fig. 29 shows such a battery. The stamp mill consists of a mortar in which the stamps work and the stamp itself. This latter consists of a stem about 14 feet in length carrying a tappet, head and shoe. The combined weight of this varies with the character of the mineral to be crushed but lies usually between 750 and 1,000 lbs. The stamp is generally raised and lowered by means of a cam, but sometimes by the direct action of a steam piston. The cams work at a speed of from 90 to 100 drops per minute and the drop is usually 8 inches.

The battery of stamps may work either wet or dry. In the former case a current of water flowing through the stamp is employed to carry away the fine material as fast as produced. Usually there is a screen-plate in the front of the mortar. The ore is fed in from behind. The capacity of the stamp battery is very much increased by having a regular feed of material and efficient feeders of special design are employed for this purpose. The frame work of the battery may be of either iron or wood.

THE CHEMISTRY OF OPAQUE GLASS AND ENAMEL.

BY R. L. FRINK.

Ceramic Engineer, Lancaster, O.

I have read, with some interest, an article in your August issue by Mr. Erik Enequist, on "The Chemistry of Opaque Glass and Enamel" and I believe that there are several discrepancies therein, or if they are not such, I would be glad to learn the detail of the chemical reaction set forth in his theory as to the cause of opal glass.

First, I note his experiment and the production of the button, sodium fluoride, at the bottom of his experimental crucible, and I should be pleased to learn as to just what was the exact composition of this button of assumed sodium fluoride, as it seems impossible that free sodium fluoride can exist in the presence of silica in the proportions as cited in his experimental batch formula.

I have done considerable experimental work along this line, and have made various attempts at producing definite sodium silicates and fluoride compositions, but so far have never been able to accomplish the results as set forth in his article.

I appreciate Mr. Enequist's article, and trust that my answer, or criticism, may not deter him from continuing to write of his experience and experiments, as I, for several years, have, through the glass trade journals, endeavored to arouse discussions on topics of this character, and anything that I may say here, I trust will be considered as a friendly discussion and criticism, which will, I believe, result in much good.

I wish also to take issue with Mr. Enequist as to his theory regarding the cause of opacity of opal glass. His statement that he has abundant proof that this is

caused by entrainment or the incorporation of gases appears to me to be somewhat ambiguous and questionable, and the one instance which he cites as a proof, namely—the heating of a piece of glass, and its becoming clear while hot, and opaque when cold—seems to me to furnish the best possible proof that gases are not the cause of such opacity.

An analogy of this property in change of color and opacity, when passing from the semi-molten to a solid condition, may be readily seen when a piece of very densely colored gold or selenium ruby glass is heated in either the oxidizing or reducing flame of the Bunsen burner and then allowed to cool. During the time that it is at a temperature above 1,200 deg. F. it will be found to be perfectly clear and void of color, but when cooled from the last insertion in the oxidizing flame, it will pass from a deep ruby to black and again to ruby. Likewise take a piece of felspar-fluoride opal, and heat a piece of this in like manner, and it will be found that it undergoes a similar transition.

If a piece of opal glass be examined under a microscope, magnifying at a power of 250 diameters, and a strong beam of light be passed through the sample at right angles to the plane of observation, it will be found that there appears to be a minute crystallization which has occurred during the cooling process. If the sample happens to be a piece of pressed ware, which has a thin section or edge which has been forced some little distance along the cold surfaces of the mold, and this edge be examined as above outlined, it will be seen that these crystals increase in numbers and decrease in size the further in to the sample the observation is made.

It is a well-known fact, to the writer at least, that silica has certain thermal limits within which it combines with the various elements, and if careful observation is made of temperatures in all experiments with the silicates, it will be found that the silicate of soda has the lowest combining temperature of any of the silicates, and, therefore, it would seem rather impossible, in view of the strong affinity which silica has for soda, that any considerable quantity of free sodium fluoride could exist in the presence of silica.

True, that in the formula given, there was 1 lb. of silica of sand, $\frac{1}{2}$ lb. of soda and $\frac{1}{2}$ lb. of fluorspar or fluoride of lime, which was fused for a "couple of hours," and the question which naturally would arise, would be—if this fusion had taken place at a temperature above the combining point of soda and silica, what was the final product of such fused combination? Surely the lime could not have broken up from calcium fluoride into calcium carbonate or oxide, and the soda have passed from sodium carbonate to sodium fluoride and silicon fluoride, and exchanged this carbonic acid with lime, without any effect whatever upon the silica. If such would be the case, it would be impossible for us to manufacture opal glass from the ingredients above named.

I agree that the opacity of glass, when made from fluorspar or cryolite, or any of the various opal

"dopes" on the market, is produced by silicon fluoride, SiF_4 , but it is the crystalline structure, and the arrangement of such crystals, which produce the opacity, and it is the assimilation of these crystals when the heating has been conducted over a considerable period of time, and the breaking up of these crystals when the same is subjected to reducing atmosphere, that changes opal glass into a clear glass.

As to the use of lead in the fixing of an opal color in the quantity of 2 per cent in a batch, this is a new one to the writer and is well worth considering, and I shall try it at my earliest convenience. It is generally assumed, however, among practical tradesmen, that lead is a poor proposition in the usual method of opal glass manufacture, namely in day tanks, in which type of furnace most of our opal glass is made, but it may be possible, as stated by Mr. Enequist, that a small proportion of lead, to the extent of 2 per cent, would act as a beneficial agent in retaining the SiF_4 in a definite crystalline condition, and also to maintain a definite color. This, however, I should assume, would be very largely dependent upon the furnace operation and fire.

Mr. Enequist's statement that the most important feature in the making of glass is temperature, is a remarkably true one, and I regret to note the absence of any figures on temperature in his article. The writer's experiments and experience in the last fifteen years have shown him that outside of ingredients, or even perhaps without this consideration, temperature and quality of fire are the most important factors to be considered in the manufacture of glass of any character, and yet it is one that is known but little of, and seldom recognized, by the tradesmen.

I note Mr. Enequist's remark—"When cullet is used in the batch a lower fusing point for the batch is recommended. If a glass fuses too easily, add either cullet or increase the felspar or cut out some soda ash or fluorspar, or both." With this statement I again take issue. In the writer's opinion there never was yet enough temperature obtained in a furnace to spoil a "batch" of any kind. A batch may be subjected to too high a temperature, but I have never been able to reach (either with coal, oil or natural gas) a temperature above my requirements. I have in numerous cases reached one so high as to put my pots in the cellar, melt them down, and make the drip of the furnace drip like a small rain storm, but in each and every instance I found that my glass improved with the higher temperature.

The second part of the paragraph quoted above, as to glass fusing too easily, and the remedy therefor, borders more upon the customs of the old-time glassmaker, who was void of knowledge of definite proportions and chemical combinations, than does it of a student of science and a ceramic chemist, for it should be known that when one departs very far from proper chemical proportions, he does one of two things which are going to give subsequent trouble—he either sets up a condition which will produce cords and not opal

glass, or a seedy glass, which, when finished and taken from the mold, is extremely difficult to anneal and place in the decorating room, or warehouse, with any degree of safety and certainty of its reaching its final destination. I believe further, that the formulas as given are far more complex than is necessary, and his characterization of soft melting and hard melting formulas with and without cullet, are not only complex but, in my opinion, unsatisfactory. This, however, is but a statement, and a snapshot opinion expressed, and I shall take the earliest opportunity to try them out. To be specific, I do not understand the double use of nitrates, as soda and saltpetre, nor do I understand the triple use of fluorides, as fluorspar, rydolith and alabastolite. The writer's experience has been that the simplest formula is by far the better one, and he usually sticks to sand, soda and the two spars, with perhaps a little nitrate, which is governed according to the amount of organic matter and the condition of his fires and furnaces.

I believe that it is a common error among the glass men, as with the old apothecaries, that to cure an anticipated trouble is to take a little of everything all the time, by which means we are sure to absorb some of a certain specific.

In conclusion I might add, that a visit to various factories using day tanks will soon convince Mr. Enequist that the best opal glass can be made in tanks wherein the flame not only comes in contact with most of the batch, but where it plays directly upon the same, and in one instance which I have in mind, the burners are inclined at an angle of 30 deg. from the horizontal, striking directly upon the pile of batch, and yet this concern has an acknowledged reputation for making a superior quality of opal glass. It must, of course, be acknowledged that this flame in striking the batch is not a reducing flame, for were it reducing, as remarked by Mr. Enequist, it would be apt to turn green, purple, or border on the blue, providing how much manganese or cobalt be used, and here again I do not understand why he wishes to use the double nitrates, nor do I understand why he should want to supplant manganese with arsenic, As_2O_3 , for the action of manganese and arsenic are not at all the same in glass manufacture, arsenic always having been supposed to be the clarifying agent, or at least so called (although the writer's personal opinion is that the old-fashioned piece of potato is equally as good) while the manganese is a decolorizing agent, which is based upon its combined action of furnishing a supply of oxygen and at the same time a neutralizing color effect by the action of the mangano-manganic oxide produced.

I would be pleased to hear from Mr. Enequist in our trade journals—*The Commoner and Glass Worker, Pottery and Glass*, etc.—as many of our practical glass men never see the columns of THE CHEMICAL ENGINEER, and at the same time I trust it will not detract him from the latter, from whose issues I have gained much valuable information.



RAPID DETERMINATION OF ASH AND PHOSPHORUS IN COKE.

By H. M. ULLMANN and N. W. BUCH.

Lehigh University, South Bethlehem, Pa.

The methods to be described have been found more rapid than the standard method¹ and other methods in vogue, they are readily carried out with the apparatus and manipulation of common usage, and they can be successfully accomplished by laboratory workers of limited insight. The results attained are constantly accurate, and, indeed, in the hands of hurried or less-experienced analysts the results are more accurate and more constant than those arrived at by longer methods exacting more painstaking precautions.

For the determination of ash, five grams of the sample of coke, which has passed a 100 mesh sieve, are weighed out in a previously weighed platinum dish of the usual round-bottom shape, of about 150 cc. capacity, or about three and one-half inches across the top. It is advantageous to spread the sample well over the bottom of the dish. From four to six cc. of alcohol are poured into the dish, and, for a moment, allowed to seep into the coke. The dish is then shaken laterally to promote uniform wetting of the sample, whereupon, the pasty mass is made to flow well up onto the sides of the dish by a slow rotary motion, the dish being held at a propitious inclination. With proper manipulation, the coke is spread in an even layer over sides and bottom of the dish and sets in that position due to the slow evaporation of the alcohol. This evaporation may be hastened by blowing on the pasty mass, and if too thick a layer is formed in any one spot, it may be thinned and levelled by blowing at it through a glass tube.

Without waiting for the mass to become absolutely dry, or, even, for all flow to cease, the dish is placed in a platinum triangle and the residual alcohol is ignited by applying the small smoky flame of a blast lamp at the top of the dish. As soon as the alcohol has burned off quietly, the dish is heated over the full brush flame of the blast lamp, the dish being set at such a height that the sides as well as the bottom are heated to bright redness. As incineration progresses, the ash flakes off the sides and drops to the bottom of the dish. Complete incineration of a five gram sample is accomplished in twenty minutes. Occasionally, specimens of coke have been encountered which show great contraction on ignition, and which have fallen from the sides of the dish before completely incinerated. In these cases the ignition is carried on for a total of thirty minutes; or, if desired, the dish may be

rapidly cooled after the first eight minutes of ignition by plunging into water, the half-burned contents again spread with alcohol, the ignition resumed and the result attained within a further twelve minutes of ignition. The use of absolute alcohol does not secure a compensating advantage. No loss of material occurs during the burning off of the alcohol or as an effect of the air-blast. The rapid combustion is due to a very gentle return eddy of hot combustion products of the blast gases which carry back a supply of fresh air. Treatment with alcohol and blast repeatedly, involves no escape of ash. Attempts to promote a comparably rapid combustion by the use of a muffle with a five gram sample spread as above, have been unsuccessful.

With a one gram sample, the above method yields accurate results in ten minutes, and it may be successfully utilized with a ten gram sample. A portion of five grams is chosen in our work because it is sufficiently large to avoid the errors due to slate and shale occasionally encountered in one gram portions; furthermore, a five gram portion is sufficient for subsequent determination of phosphorus. Weighings of dish, coke, and ash, for a sample of five grams of ordinary coke, may be made rapidly within one-half milligram, involving an error, at most, of 0.01 per cent in the result.

To proceed with the rapid determination of phosphorus, the dish is tapped gently a few times to loosen any adhering ash. Ten cc. of concentrated nitric acid are poured around the sides of the dish, 10 cc. of water are added, and then, 3 to 5 cc. of hydrofluoric acid. The dish is covered with a watch crystal and is evaporated by boiling to a volume of less than 10 cc., or to about 5 cc., requiring about 10 minutes. Thirty cc. of hot water are added, the contents boiled for 5 minutes, and then filtered into an Erlenmeyer flask, washing from 4 to 6 times. In a number of cases tried, the boiling with water could be omitted and replaced by the simpler addition of hot water and a thorough stirring. Occasionally, the first runnings of the filtrate are cloudy, which does no harm; but, if desired, this may be overcome in every case by simply refiltering the first runnings. The above simple and rapid treatment has been found to yield all the phosphorus in a properly oxidized condition, without retention in the residue of calcium phosphate, and without danger of co-precipitation of silico-molybdates.

From this point onward, the precipitation and titration progresses by the well-known alkalimetric method for phosphorus. Ammonia is added until a slight precipitate ensues; this is just dissolved with nitric acid;

¹Jour. Am. Chem. Soc. 21, 1116.

the solution is heated to 85° C.; 50 cc. molybdate solution are added; the flask is wrapped and shaken for five minutes, and then at intervals during ten further minutes. Five minutes of shaking are insufficient with samples of varying phosphorus content; although this shorter time might well yield excellent results in coke from any single source, particularly if the alkaline solution be standardized against a coke of like origin and similar phosphorus content. The precipitate of phospho-molybdate is washed six times with a 2 per cent solution of potassium nitrate, or until free of acid, and is then returned to the flask and titrated with the standard sodium hydroxide solution. This standard solution is conveniently made equal to 0.00025 gram phosphorus or 0.005 per cent in the five gram sample, and was found to be 0.995 of one-fifth normal.

The above methods for ash and phosphorus had proven satisfactory in many specimens of Pennsylvania coke, and we are indebted by the kindness of Professor N. W. Lord and Mr. F. W. Stanton of the United States Geological Survey for twenty samples of coke from various states. Comparative results with the Survey determinations in these samples, calculated to original moisture content, are as follows:

No.	State.	U. & B.	U.S.G.S.	U. & B.	U.S.G.S.
		Ash.	Ash.	Phos.	Phos.
		P. C.	P. C.	P. C.	P. C.
1.	Pennsylvania ..	8.94	9.06	0.006	0.008
2.	Illinois	10.02	10.09	0.007	0.007
3.	New Mexico...	14.01	14.21	0.106*	.....
4.	Virginia	5.49	5.60	0.006	0.008
5.	Pennsylvania ..	10.32	10.48	0.010	0.010
6.	Illinois	15.79	15.92	0.016	0.016
7.	Pennsylvania ..	14.36	14.35	0.009	0.009
8.	West Virginia..	12.41	12.24	0.009	0.008
9.	Pennsylvania ..	11.49	11.47	0.014	0.015
10.	Pennsylvania ..	11.85	11.78	0.015	0.015
11.	Pennsylvania ..	14.44	14.68	0.055	0.055
12.	Tennessee	22.59	22.52	0.072	0.068
13.	Illinois	11.34	11.44	0.006	0.007
14.	Pennsylvania ..	10.76	10.75	0.013	0.016
15.	Georgia	17.40	17.21	0.008	0.011
16.	Alabama	6.68	6.62	0.041	0.038
17.	Virginia	11.94	12.17	0.008	0.008
18.	Alabama	9.57	9.48	0.052	0.051
19.	Alabama	17.22	17.20	0.007	0.008
20.	Ohio	10.61	10.45	0.006	0.007

*Gravimetric, 0.107 per cent.

We acknowledge with gratitude the able assistance rendered by Mr. Richard Joyce and by Mr. J. M. Sanderson in the development of the above methods. An investigation applying the same principles to coal of diversified kinds from various localities is now in progress and is yielding wholly satisfactory results.

Lehigh University, South Bethlehem, Pa.

RAPID ANALYSIS OF BABBITT METAL.

In the August issue of the *Journal of Industrial and Engineering Chemistry* Messrs. Percy H. Walker and H. A. Whitman propose the following scheme for the analysis of babbitt metal. The novelty of their procedure depends upon the employment of a separate portion of the alloy for each determination and the complete solution of the metal in each instance before it is determined. The authors have very thoroughly tested the method and obtained better results with it than with other technical methods. The details follow:

Copper.—Weigh 1 gram of the alloy into a 250 cc. beaker, add 20 cc. hydrochloric acid and 5 cc. of water, heat and complete solution by adding nitric acid in small amounts; with most alloys solution can be effected in a very few minutes and without adding more than 1 or 2 cc. of nitric acid. Evaporate off the acid on a steam bath. It is not necessary to carry to complete dryness, but practically all the acid should be driven off and the residue should be pasty. Add 25 cc. of a solution made of 200 grams tartaric acid, 260 grams of potassium hydroxide, the whole being made up to 500 cc. with water. Heat on the steam bath until solution is completed, add 25 cc. water, boil, add 25 cc. of a 0.2 per cent invert sugar solution, boil for two minutes, filter through asbestos, wash the precipitate of Cu_2O with water, dissolve in nitric acid, catching the copper solution in a 200 cc. flask, and determine copper by any good volumetric method. We have found that equally good results can be obtained by following Low's iodide method, or by Jamieson, Levy and Wells' thiocyanate and iodate method. The results are uniformly a little low. This error is not due to volumetric methods employed, both of which give exceedingly accurate results; but nearly 6 per cent of the copper present is not precipitated as Cu_2O . This loss is uniform for if we add 6 per cent of the copper determined, the result will be the per cent of copper in the alloy.

The statement is frequently made that if a Babbitt metal is decomposed by nitric acid, evaporated to dryness, taken up with nitric acid and filtered, that copper can be determined in the filtrate with an error of not more than one or two-tenths of 1 per cent. This is not the case, the error with any alloy containing 5 per cent of copper will frequently be from 0.5 to 0.7 per cent, while by the method described above without correction the error will be less than 0.3 per cent, and by applying the correction this error is removed entirely.

Lead.—Dissolve 0.5 to 1 gram alloy in a 250 cc. beaker as in the determination of copper, when solution is complete evaporate to dryness on the steam bath, add 5 cc. strong hydrochloric acid (with as much as 10 per cent Sb use 10 cc. HCl), warm for a few minutes, remove from steam table, add, with stirring, 150 cc. 95 per cent alcohol, let stand at room temperature for 2 hours, filter on a Gooch crucible, wash with 95 per cent alcohol, using about 100 cc. Suck as dry as pos-

sible, dry crucible in an air bath (one hour at 105° C. is sufficient, though the lead chloride can be heated at 150° with perfect safety). Weigh as $PbCl_2$, add 0.0085 gram to the weight of the precipitate and multiply by 0.74473, the product gives the weight of lead.

The method of separating lead as chloride has been used by several authorities: G. W. Thompson, separates as chloride and then determines as chromate. Olsen, separates and weighs as chloride. Neither of these authors, however, give methods which can give correct results, for the solubility of lead chloride in mixtures of alcohol and hydrochloric acid seems to have been overlooked by both. This may cause errors of several per cent if the conditions are not made uniform and allowance made for the lead chloride dissolved. The amount of acid present is also of importance. If a large amount of hydrochloric acid is present the liquid will dissolve more lead chloride; if too little acid is present there is danger of precipitating oxychloride of antimony or tin. We have found, however, that the above proportions of acid and alcohol will cause no precipitation of metals other than lead and will dissolve an amount of lead equal to the correction applied. This holds true for alloys high in lead and for alloys high in tin.

Antimony is best determined by W. H. Low's method which we have slightly modified as follows: To 1 gram alloy in a 450 cc. Erlenmeyer flask, add 10–15 cc. strong sulphuric acid, and heat on hot plate until alloy is thoroughly decomposed. This is generally accomplished in about 30 minutes from the time fumes of SO_2 begin to be given off. Cook, add 200 cc. water and 20 cc. strong hydrochloric acid, boil to make sure that all SO_2 is driven off, cool and titrate rapidly with potassium permanganate which has been standardized against metallic antimony. The true endpoint is when a pink color shows after agitating the liquid, though this pink will very soon disappear. The only change we make in the Low method of procedure is to add somewhat less hydrochloric acid. The results are sufficiently accurate for commercial purposes, but the tendency is to get results 0.3–0.4 per cent high.

Tin is also worked by W. H. Low's method, except that we have found it more satisfactory to use a separate portion of the alloy and reduce with steel turnings instead of with metallic antimony. Treat from 0.2–1 gram of alloy (do not use an amount of alloy containing more than 0.2 gram tin) in a 450 cc. Erlenmeyer flask with 10–15 cc. strong sulphuric acid, heat on the hot plate until the alloy is thoroughly decomposed, cool, add 200 cc. water, 30 cc. strong hydrochloric acid, and about 1 gram of steel turnings, heat and when reduction appears complete, but before the last particles of steel have dissolved, place a two-hole rubber stopper in the neck of the Erlenmeyer flask—one hole of the stopper should carry a tube reaching below the surface of the liquid, the other hole should carry the short arm of a bent tube, the long arm of which reaches nearly to the bottom of a 100 cc. Erlen-

meyer flask containing a solution of sodium bicarbonate. This small Erlenmeyer is held on the bent tube by a cork which has a notch cut in it to act as a vent. Through the tube reaching below the surface of the liquid in the large Erlenmeyer pass a current of carbon dioxide, heat to boiling until all steel is dissolved, continue passing CO_2 and cool as quickly as possible; loosen stopper but let current of CO_2 continue, add cautiously some starch solution and titrate with $N/10$ iodine. It is necessary to absolutely exclude air and to standardize the iodine solution with pure tin. Results are accurate.

THE DETERMINATION OF TOTAL SULPHUR IN GAS.

By MR. L. B. MOOREHOUSE.

This paper will outline and compare two methods for the determination of sulphur in illuminating gas, giving the essential features, chemical equations and calculations involved in each. For the detailed description of apparatus and method of manipulation of tests, the reader will be referred to text-books on the subject. The best known method for the determination of total sulphur in gas is that given in the "London Referees Test for Purity." For a detailed description of the test, see "Gas Analyst's Manual," by Abady or "The Chemistry of Gas Manufacture," by H. M. Royle.

Briefly, this test consists in burning 10 cubic feet of gas at the rate of $\frac{2}{3}$ cubic foot per hour in an atmosphere impregnated with fumes of ammonia and collecting the condensable products of combustion. These drippings, containing ammonium sulphate and ammonium carbonate, formed from the union of NH_3 with CO_2 and SO_2 , are then treated with a dilute solution of hydrochloric acid and boiled, after which a solution of barium chloride is added and the boiling continued. The barium chloride converts the ammonium sulphate into the insoluble barium sulphate, leaving the soluble ammonium chloride. The washings are first acidulated with hydrochloric acid and boiled, so that the ammonium carbonate may be changed to the soluble chloride of ammonia, thus avoiding throwing down the insoluble barium carbonate with the barium sulphate.

By filtering out the precipitate and washing same with hot water, until all of the soluble salt is dissolved away, we are left only the barium sulphate. The filter holding same is now dried, burnt and weighed. The weight in grams of

$$\frac{BaSO_4 \times 15.43 \times \frac{32}{233} \times \frac{100}{\text{ft. gas used}}}{100 \text{ ft. gas.}} =$$

grains sulphur

The reason for above calculation is as follows: One gram contains 15.43 grains; the atomic weight of sul-

phur being 32, and the molecular weight of BaSO_4 233, each gram of BaSO_4 contains $\frac{32}{233}$ parts of sulphur. The gas is, of course, corrected for temperature and pressure.

If it is desired to test unpurified gas, obtaining the hydrogen disulphide separate from the organic sulphur, the gas may be run through a referees' test, as above described, and the total sulphur obtained. A separate sample of the same gas may be subjected to a test for H_2S , and the difference will of course be the CS_2 and other organic sulphur. The Tutweiler test will serve as a rapid method of obtaining H_2S . It consists in measuring 100 cubic centimeters of gas into a burette containing a starch solution, and letting into the same burette a measured quantity of iodine solution of known strength. The reaction is as follows: $\text{H}_2\text{S} + \text{I}_2 = 2\text{HI} + \text{S}$. The completion of the reaction is indicated by the characteristic blue color.

Suppose a solution of iodine containing .001707 grams to each cubic centimeter is used, and 100 cubic centimeters of gas taken.

One cubic centimeter of gas equals approximately $\frac{1}{283}$ cubic feet

Atomic weight H equals	1
" " S "	32
" " I "	126

Then, each cubic centimeter of iodine used represents

$$.001707 \times 15.43 \times 282 \times 100 \times \frac{34 \text{ grains } \text{H}_2\text{S}}{252 \text{ 100 feet}}$$

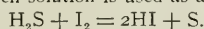
or 100 grains.

For a detailed description of Mr. Tutweiler's apparatus, see pages 252-255, Vol. 1., Proceedings American Gas Institute.

The second method for the total determination of sulphur is one originated, and first employed by Mr. W. B. Calkins, at the Laclede Gas Company, St. Louis, Mo. A description of the apparatus may be found in "Handbook of American Gas Engineering Practice," by Latta. It consists in passing the gas over incandescent, platinized asbestos or pumice stone, then through an ammoniacal solution of cadmium or zinc chloride.

The platinized pumice serves to cause the organic sulphur to break up and unite with the H of the gas, thus changing it into H_2S , after which, according to the formula, $\text{CdCl}_2 + \text{H}_2\text{S} + \text{TNH}_4\text{OH} = \text{CdS} + 2\text{H}_2\text{O} + 2\text{NH}_4\text{Cl}$, the sulphur is collected as CdS.

The CdS is then received into a large beaker, containing a quantity of cold distilled water, and treated with strong C.P. hydrochloric acid. The acid changing the CdS to H_2S , we are able now to titrate with iodine. A starch solution is used as an indicator.



Suppose we have passed .08 cubic foot of gas (cor-

rected) and have used 7 cubic centimeters of an iodine solution of a strength of 1 gram iodine to 50 cubic centimeters of water.

Since atomic weight of I equals 126

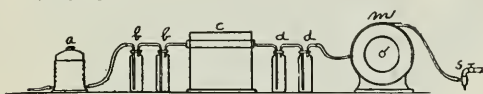
" " " S " 32

and as 1 cubic centimeter iodine solution represents

$$\frac{1}{50} \times 15.43 + \frac{32}{2 \times 126} \text{ grains sulphur, or } .0393 \text{ grains.}$$

$$\text{Therefore, } \frac{\text{grains sulphur}}{100 \text{ feet gas}} = \frac{.0393 \times 100 \times 7}{.08} = 344.$$

In making up the iodine solution it is best to standardize it against some positive standard as barium thio sulphate. $\text{BaS}_2\text{O}_3 \cdot \text{H}_2\text{O}$. If it is desired to obtain the H_2S separately from the other sulphur, the apparatus may be set up as indicated in the accompanying figure.



A represents gas governor; bb are absorption cylinders containing cadmium chloride for the absorption of H_2S ; C is the combustion furnace; dd absorption cylinders containing more CdCl solution for taking out the remaining sulphur compounds; m is the meter and S the water suction pump for drawing the gas through the train of apparatus.

This Calkins apparatus has been tested and found to give results which check out closely with the referees' method. To set up the apparatus and make test requires less than $\frac{3}{4}$ of an hour, while the referees' test must run for hours—if according to instructions, for 15 hours. This rapidity of operation enables the gas man to determine on short notice the condition of his gas. If it is desired to obtain the sulphur in gas as it averages for a lengthy period as is given by a referees' test, this may be accomplished by storing the gas in a gasometer.

To laboratories already equipped with a test meter and governor the cost of a Calkins outfit would be about \$25, while the referees' apparatus, including balance, would be about twice this amount.

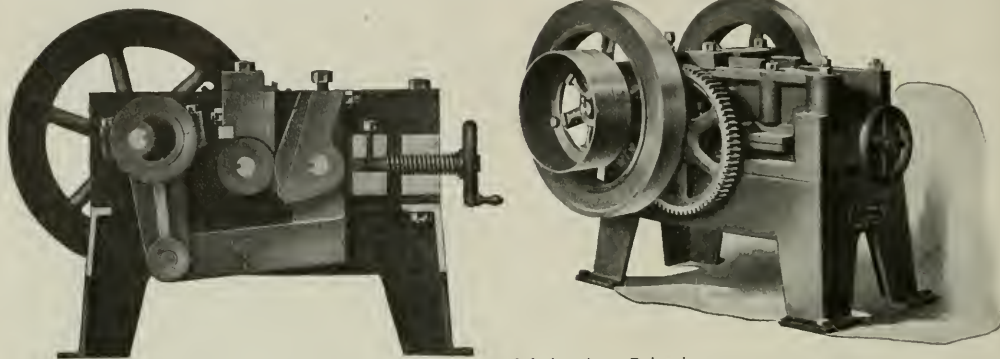
One of the notable applications of asbestos in recent years is as a pigment under the name "asbestine," and the investigations of the scientific section of the Paint Manufacturers' Association of the United States show that asbestine is a most valuable pigment. On account of its fibrous structure it has the property of holding up other heavier pigments in the paint. It possesses "tooth" or "feel under the brush," is very stable, may retard chalking, and apparently gives increased strength to the paint coating; when used with paint containing lead and zinc it adds certain properties which no other pigment can give. It has a use today in high-grade paints. However, the proportion which should be used should be moderate. If used in excess it cheapens and adulterates the paint.

NEW LABORATORY APPARATUS.

Sample Grinder.

The two cuts show a new form of laboratory pulverizer which has been devised by the Fulton Machine Co., Canal Fulton, Ohio. This is designed to prepare samples for laboratory use, breaking down such substances as glass, limestone, manganese, iron ore, cement, or coal by one operation, from cubes $1\frac{1}{2}$ inches square to a powder which will all pass a 120-mesh sieve. This may be done with the Fulton pulverizer

the Bausch & Lomb Optical Co.) two bottles of 500 cc. capacity each may be carried at one time, and smaller containers in greater number. The case is made of iron, and is in three pieces to facilitate taking the instrument apart for cleaning and also for convenience in placing different bottles in position. Further, it has been found that by entirely enclosing the centrifuge, higher speeds can be obtained, owing to decreased resistance, as the revolving arms no longer act as fans, because the outside air is excluded by the



Section and End View of Laboratory Pulverizer.

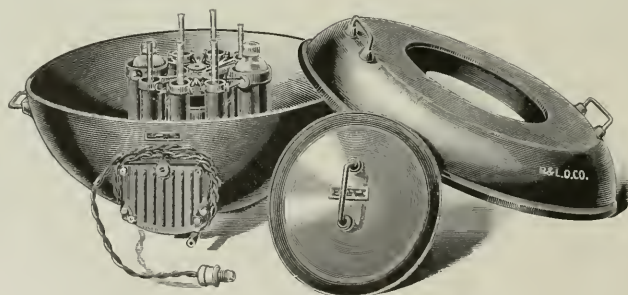
at the rate of about one pound per minute. The Fulton laboratory pulverizer is intended to take the place of both the mortar and the crusher and has proved efficient. It has been used in a large number of laboratories among which may be mentioned those of the Salem Iron Co., Leetonia, Ohio; The Halcomb Steel Co., Syracuse, N. Y., and the United States Steel Corporation. The latter company has eight of these machines in their chemical laboratories. In this pulverizer the crushing is done by the jaw and the fine pulverizing by the roll.

Precision Centrifuge.

The need for a centrifuge capable of considerable

cover. The case is $27\frac{3}{4}$ inches in diameter, and $16\frac{1}{4}$ inches in height. The parts fit tightly together, and the case is strong enough to absolutely prevent any injury to the operator in the event of breakage. The case is finished in a durable black and presents a pleasing appearance.

When supplied for direct current, the motor, of heavy construction and with the armature spindle mounted on ball bearings, is contained in the case. The head of the centrifuge is mounted on the spindle and is of such design as to carry various sizes and styles of trunnions, these being made suitable for the kinds of flasks used in different sorts of analysis. By simply



Precision Centrifuge.

removing the top, the trunnions may be easily removed and the containers taken out of the centrifuge. The electric Precision Centrifuge for alternating current is mounted on an iron base with an exterior motor which drives the apparatus by a belt.

range of speed and with sufficient power to carry various forms and sizes of flasks and bottles, has long been felt. The electric centrifuges offered heretofore have been equipped with but two tubes, each of small capacity. In the centrifuge shown (manufactured by

removing the top, the trunnions may be easily removed and the containers taken out of the centrifuge. The electric Precision Centrifuge for alternating current is mounted on an iron base with an exterior motor which drives the apparatus by a belt.

METALLURGY.

VANADIUM STEELS

THEIR CLASSIFICATION AND HEAT TREATMENT.*

The element vanadium has within the past few years sprung from the position of a scientific curiosity to that of a metal which, suitably harnessed, has marked an epoch in the history of the steel trade.

The existence of the element was first recognized in 1801, by Del Rio, of Mexico, who named it erythronium. His observations were generally discredited by contemporaneous chemists. Thirty years later Sefström of Sweden found the element in his native iron ores and in honor of one of the Scandinavian deities called it vanadium.

Several decades passed before the element was isolated by Sir Henry Roscoe, who made a study of its compounds, which were used to a small extent in dyeing, tinting glass, etc., though such use was necessarily costly.

The pure metal is silvery white in appearance and of very high melting point, its value being almost entirely academic. It was observed, however, that an alloy of vanadium and iron in the respective proportions of one to two had a comparatively low melting point and that the judicious use of the element in *small quantity* conferred marvelous properties upon steel. This at once opened the door to its probable utility in the service of man.

A demand having been indicated, a supply was soon forthcoming, owing to the discovery and development of an immense deposit of very high-grade vanadium ore of a type unique even to mineralogists, so that ferro-vanadium is now available as a market article in any quantity. From having a value many times that of gold, vanadium is now, mainly owing to increased production and to improvements in the processes of manufacture of the alloy, procurable at a price (reckoned on its net weight), about half that of silver.

Of necessity, therefore, vanadium steels cannot be low-priced in first cost, but in view of the facts that to obtain the best effects it is only necessary to use vanadium in proper combination in "homeopathic" doses, and that vanadium steels are meant to meet requirements with which admittedly the best classes of ordinary steel are powerless to cope—and which even the highest classes of previously known steels of the most expensive character were unable to successfully meet in many directions—it is evident that owing to the greatly increased demands made by modern engineers, a wide scope is opened out for its use and that this field is daily growing wider.

USEFUL STRENGTH IN STEEL.

It had been the custom for many years to form an

opinion of the qualities of steel by its behavior when subjected to a steady load or a slowly applied bending action, that being considered the best metal which was strong and ductile, stretching greatly before breaking under a steady pull, and bending without breaking. Ductility could be maintained in steels of ordinary composition up to a certain strength, but beyond this the metal became brittle.

Steels were next prepared in which much higher resistance to load could be attained before brittleness was reached, through the use of various alloys. But it soon became apparent that in many cases the ductility thus attained did not necessarily imply a certainty that the metal would behave well under stresses applied in a different manner. Statically ductile steel fractured sometimes like glass under the influence of shock, whether so severe as to be termed "overwhelming" in nature, or much lighter and continually repeated, or even under the influence of constant vibration.

The needs of the engineer of to-day demand, with increasing force, strong steel which shall be enduring under such conditions as the latter, and it has become obvious that the same basis of judgment should not be taken literally in indicating the suitability of materials for such widely different purposes as—to take two typical examples—the manufacture of (1) bridges and (2) locomotive connecting rods.

In modern machine construction, especially in those parts which are liable to failure in service, it is after all "*dynamic*" superiority that is the essential consideration, namely, resistance to repeated stresses, to alternating stresses, to simple or repeated alternating impacts, and to fatigue (which latter is the outward visible sign of molecular disintegration). Thus a new field has been opened out and in this field vanadium was found by extended experiment and prolonged practical experience to be pre-eminent, in fact to stand alone.

Vanadium statically intensifies tremendously the strengthening power of another ingredient, enabling such a small quantity of that ingredient to be used as to not dynamically poison the metal; in itself, it confers remarkable dynamic properties to steel; it retards "segregation," and so renders steel particularly susceptible to the highly important improvements due to tempering; utilizing this same characteristic, steels can be prepared by natural means which are very, resistant to wear and erosion; it toughens steel, and confers to it great powers of resistance to torsional rupture; in a word, it endows it with the quality of "life" in practical work.

"DYNAMIC" TESTING OF STEEL.

In this form of test, the test piece, held securely at

*Abridged from a treatise by J. Kent Smith. Courtesy of the American Vanadium Company.

one end in a vise, is moved backwards and forwards by means of a slotted arm which communicates to the piece successive permanent distortions in each direction, such distortion having been produced by means of an impact followed immediately by a pushing motion. As a result, the test piece is fractured finally on the line of the vise, at which point the severest stresses are created. The slotted arm moves on a crank, so that the pushing motion is performed without the interfering factor of "rub," as the slotted arm describes the same arc as the distorted test piece.

It has been objected by some engineers that, as in commercial work they never anticipate the stresses on metal parts to even approach the elastic limit of the metal, this test has no bearing on service conditions. On the other hand it is universally conceded that the great majority of service fractures are caused by strains which are repeatedly applied, thus resulting in the molecular deterioration of the metal. Furthermore, it is allowed that the nearer such repeated stresses individually approach in degree the elastic limit, the rate of deterioration is enormously increased. Hence, by submitting a metal to rotary vibration against an overhanging weight, unless the fiber stress thus communicated in each case bears a strict relation to the elastic limit of the metal under investigation, the figures obtained are so obscured as to render the results valueless for purposes of comparison. In addition, many other factors influence the results of a rotary test, such as fluctuation in the rate of rotation, "whipping" of the sample, deviation from true alignment, swinging motion of the overhanging weight, and the method of the initial application of the same, which all tend to further render the results of the test non-comparable.

The function of the alternating impact test is to rapidly tear apart both from each other and in themselves the constituent "crystals" of the metal of the test piece, and as a result, the inherent value of the metal, in resisting molecular deterioration, is obtained. Thus, although the alternating impact test would at first sight appear to have nothing in common with practical conditions, the identical results required for successful service performance are obtained. Without elaborating further on this matter, it will be sufficient to refer any interested persons to the prolific work of Professor Arnold, Professor MacWilliam, Mr. J. T. Milton, Mr. W. L. Turner and many others, on the service value of the test.

It has already been said that the rate of deterioration advances enormously as the conditions are more drastic, and therefore direct readings of the alternating machine should be taken in some measure of geometrical proportion, rather than in arithmetical proportion, in deducing "life" value, as a progressive or detailed fracture is produced in the course of a couple of minutes on the testing machine in question.

EFFECT OF VANADIUM.

Vanadium steels of numerous types are being made regularly by the progressive steel mills of the world

and the properties of the steels obtained fully substantiate the published tests.

Vanadium exerts its power in at least three ways:

1. It indirectly toughens steel owing to its powerful scavenging action, removing oxides, nitrides, etc., in a fusible form easily carried away to the slag. In this respect, it differs markedly from some other de-oxidizing alloys.

2. It directly toughens steel mainly by its solid solution, under normal conditions, in the carbonless portion known as ferrite. To succeed in this respect, the alloy must either contain free vanadium, or vanadium combined with some other element which also goes into solid solution in ferrite under normal conditions, such as silicon.

3. It forms complex carbides of such nature as to statically greatly strengthen the steel containing them. These carbides are proved to add more strength to steel when they contain chromium or nickel.

There is no one type of vanadium steel that does all things. It is necessary to make various kinds and grades for different purposes and hereinafter will be found a list of the purposes for which different vanadium steels have been successfully applied, with instructions as to their proper heat treatment to meet specified requirements.

In the tables presented, with regard to composition and heat-treatment, the results have been *mainly* deduced from experience with basic open-hearth chrome-vanadium steels and are corroborated by service records and by exhaustive microscopic investigation.

"ATMOSPHERE" INFLUENCE IN STEEL MAKING.

It has long been known that steels of the same analysis but made by different processes, vary considerably in their mechanical properties. No attempt to form any correlation on this point had been made until Prof. F. W. Harbord of London, England, in the latter half of 1907, published carefully observed data on the tensile and hardness investigations of acid Bessemer, basic Bessemer, acid open-hearth and basic open-hearth steels, without, however, attempting any explanation of the observed phenomena. In the ensuing discussion, two suggestions were made: First, that oxidation, and second, that heat of refining, were the cause of the differences. But both suggestions are untenable, as forming the basis of complete explanation in the light of our present knowledge.

Two other possible—and probable—causes of difference are (1) the nature of the atmosphere in which the steel was refined, and (2) the nature of the slag covering the steel bath, and of the material forming the container of the molten steel, with the consequent extent of such atmosphere being transmitted to the steel bath in radiation or conduction processes.

It is generally admitted that some of the finest possible steels are the product of the coke fired "white" pot. The latter, as has been abundantly proved, is porous to gases, and the atmosphere surrounding the steel must in this case be one of nitrogen and carbonic oxide. The product of a gas fired crucible furnace in

which *black-lead* pots are used should be identical in nature, provided the analysis of the material coincides.

In the electric furnace, a somewhat similar atmosphere prevails, and its product is comparable in all ways with the best crucible steel of similar composition, while its units are of much greater dimensions. It is almost entirely the questions of this atmosphere and of complete deoxidation that endow the steel made in the electric furnace with such high attributes, and these are in no way due to the imparting of any especial virtue by the electricity, per se, which is used only as a heating agent. It will thus be seen that the electric furnace is pre-eminently suited to the production of the highest grades of alloy steel, in which it is a *sine qua non* that a most excellent base be used.

Whatever be the cause of difference, however, for given tenacity with regard to similar composition, the writer would place steels made by different processes in the following order of stiffness:

1. Coke fired crucible ("white" or "black lead" pot).
- Gas fired crucible ("black lead" pot).
- Electric furnace.
2. Bessemer acid.
3. Bessemer basic.
4. Open-hearth acid.
5. Open-hearth basic.

While the product of the Tropenas converter, acid lined, very strongly resembles in nature that of the acid Bessemer, it differs from it in some respects. If there is anything in the question of atmosphere, this is exactly as would be expected.

The production of special steels may practically be limited to the output of the open-hearth and crucible processes.

HEAT-TREATMENT FOR VANADIUM STEEL.

The term "heat-treatment" is of comparatively recent origin. Strictly, however, it covers processes which have been practiced for many years, namely

Annealing, and
Tempering.

The extension of the term to include such manipulation by heat as will either wholly or partially restore a steel which, owing to mechanical, thermal, or service conditions, has become dangerously crystalline and brittle—a question full of controversy at the moment—should not really enter into the heat treatment of newly-made or of unused steels.

Before dwelling on the commercial phase of the subject, the ultimate structure of a piece of constructional (or "sub-saturated") steel, under normal conditions, will be considered in as elementary and non-technical manner as possible. Such steel consists primarily of iron, with more or less carbon, some sulphur, phosphorus and manganese, and possibly, silicon, nickel, chromium or vanadium, in addition.

The carbon therein contained is combined chemically with a molecular proportion of iron. A molecule of this chemical compound alloys itself with twenty-one atoms of carbonless iron and the resultant alloy is

distributed in lumps, or in mesh form, through the main background of carbonless iron. The alloy, or eutectoid, is known technically as pearlite, and the free carbonless iron as ferrite. The precise manner in which this pearlite is arranged in respect to size, plate-like form, regular or irregular distribution, etc., depends to a considerable degree on the nature and amount of "hot work" put on the steel, the rate of cooling, and so on.

Part of the manganese unites chemically with the sulphur (also possibly with some of the silicon of the steel, the resultant compound forming striae, or globules throughout the mass.

The phosphorus and the remainder of the silicon, and, if used, a large part of the nickel, are dissolved in the ferrite, in the form known as "solid solution."

Chromium is found as a constituent of the pearlite.

Vanadium is found partly in solid solution in the ferrite (free and constituent in the pearlite), which it toughens, and partly in the carbide portion of the pearlite, which it strengthens.

If heat be applied to a bar of normal steel, it will become sensibly hotter with each successive increment of heat up to a given point. Thereupon further application of heat causes a molecular rearrangement instead of increasing the sensible temperature of the steel; the pearlite becomes broken up, its carbides going into solid solution in the ferrite. When such decomposition and solution are complete, sensible temperature of the steel again rises as heat is applied.

In cooling the steel, the converse takes place. To a certain point, the steel cools regularly; then it apparently ceases to cool, its dissolved carbides being thrown out of solution, and allowing themselves with ferrite to reform pearlite. When the carbides are completely thrown out of solution, sensible cooling again regularly proceeds.

Such is a brief explanation of the phenomena of calescence and recalescence.

The object of annealing is to break up the carbide areas and distribute the same in small colonies. Wherefore, the steel should be heated above the calescence point, this temperature being maintained long enough to thoroughly decompose the pearlite, as well as to remove any strains that may have been locked up in the mass during mechanical operations; it should then be allowed to cool slowly through the recalescence point, due precautions being taken to prevent chilling, etc. The less sandwich-like the formation of the pearlite thus reformed, and the more granular (or "sorbitic") the colonized carbide areas, the better the annealing.

A vanadium ferrite does not permit of the ready passage through it of the carbides precipitated at the recalescence point; therefore the colonization of carbides in such steel is much less complete and their distribution better; consequently, the toughness and tenacity of the steel is increased, irrespective of the added toughness of the background of vanadium ferrite.

If the steel heated above the calescence point (when

it contains all its carbides in solid solution), be subjected to very quick cooling, so that no chance is given for the deposition or reprecipitation of its dissolved carbide, a new body is formed known by the generic term "martensite"; in other words, martensite may be said to consist of a frozen solution of carbides in ferrite. In its nature, this body is brittle and intensely hard. The intensity of its hardness, however, naturally varies both with regard to the nature and amount of carbides contained in the frozen solid solution, and to their rate of freezing.

For most machinery purposes, it is better to make this sudden abstraction of heat by quenching in an oil-bath. Quenching in water certainly results in the quicker abstraction of heat and in the formation of a more intense martensite, but water quenching is very apt to give rise to the formation of small (they may be microscopically small) cracks, which militate severely against the useful performance in service of the steel which has undergone this process of quenching.

Under certain conditions, oil may be replaced, with more or less advantage, by different aqueous solutions; this course is resorted to when it is desired to impart a more intense hardness to the material than can be attained by quenching in oil and at the same time to avoid the formation of the minute cracks due to ordinary water-quenching.

In passing, it should be noted that steels containing considerable quantities of chromium and manganese together are particularly liable to give rise to cracks when quenched in water.

Martensite is not a stable "body," its equilibrium being destroyed very much below the calescence point; when subjected to a temperature of about 360 degrees Centigrade, for a period of time sufficient to thoroughly soak through the mass, it is decomposed, its carbides being deposited in situ and soft ferrite liberated as a background. As the temperature applied in this tempering (or "letting down") heat is increased, the carbides begin to flock together, the rate increasing much more rapidly as the tempering heat is augmented.

At the calescence point the deposited carbides once more go into solid solution, and are again precipitated on cooling the steel; if such cooling be slow, the phenomena of an annealed steel are obtained. Hence, it will be seen, that the oil tempering operation, which consists essentially of the two processes of quenching and of letting down (or drawing back), must be practiced so that the letting down is never performed at or above the calescence point, otherwise the virtues due to the oil tempering are entirely lost.

It would be well to observe in connection with this drawing back, or letting down, process, that it can be accomplished elegantly at low temperatures in an oil bath kept at the requisite temperature by means of a fire or gas burner.

An excellent way of drawing back small quenched articles, which are required to be let down at a higher temperature than is consistent with the use of hot oil,

is to immerse same in a bath of molten lead, which latter is kept at the desired heat by means of a fire.

Drawing back may also be accomplished, for both large and small articles, by immersion in a furnace which is *already at the desired temperature, maintaining such heat during the prescribed period.* The recalescence points of similar steels, made by the different processes hereinbefore mentioned, being substantially the same, the annealing treatment recommended is applicable in all cases. When it comes to temper, however, three facts must be considered:

1. That the stiffer steels when quenched form more intense martensites.
2. That some quenching liquids are more drastic than others.
3. That the more intense the martensite, the more decomposing it takes, other things being equal.

In the treatments hereinafter recommended, the figures given are with respect to quenching in lard oil, or a mixture of lard and fish oils, which mixture will be found very satisfactory.

The oil is generally contained in a tank which is water cooled, so that the temperature of the bath is usually about 50 to 60° C., or in some cases, possibly a little higher. It is not absolutely necessary that lard and fish oils be used alone, as it is admissible to add a considerable quantity of cotton seed oil, etc., but the characteristics of such mixture of lard and fish oil should be adhered to as much as possible; for example, the admixture of any class of medium-thin paraffin oil would not be recommended.

A more drastic quenching liquid than the above, would be cold water, which, however, for reasons already explained, is not recommended for structural steels, while iced brine and quicksilver are still more drastic in their cooling action. Even in the case of cold water, the temperature from which the steel is quenched must be about 50° C. to 150° C. less (always keeping it above the calescence point, of course) than if the quenching were done in oil, in order to obtain the same degree of martensitic formation.

It is apparent that if absolutely the same composition be followed irrespective of the process of manufacture, as the stiffer steels form martensites which require more breaking up, the drawing-back temperatures in tempering should be correspondingly somewhat lower, or both, so that the final results may in each case be equal. Similar remarks apply if two steels be made by the same process, one of which is somewhat stiffer than the other owing to composition.

Conversely, if quenching and drawing-back temperatures are kept constant, then the figures on the table which apply to the composition of basic open-hearth steels must be modified somewhat in their stiffening elements, according to the process of manufacture, so that the final results be the same.

Such modifications in composition are approximately given in tabular form.

The stiffening elements may be said to be carbon, manganese, chromium, and part of the vanadium. It

is assumed that the phosphorus and sulphur, the former especially, remain reasonably low in every case.

Taking an example: If acid Type D chrome-vanadium spring steel be made, and is to be subjected to the heat-treatment indicated in the table, the carbon should be kept in the neighborhood of .40%, the chromium should be kept down to but little over 1%, while the manganese content should be about .80%. If on the other hand, the Type D composition shown on the table for basic open-hearth steel be used in the case of acid steel, the quenching in oil of the resultant spring bar should be done from a temperature of about 850° C. and the drawing-back performed between 450° C. and 550° C.

TABLE OF COMPARATIVE COMPOSITIONS (APPROXIMATE).

	Acid.	Basic.	Crucible.
	%	%	%
Type "A," Regular			
Carbon	.23	.27	.21
Manganese	.40	.45	.40
Chromium	1.00	1.00	1.00
Vanadium (contained).....	.16	.16	.16
Type "A," Mild			
Carbon	.20	.23	.18
Manganese	.35	.40	.35
Chromium	.90	.90	.90
Vanadium (contained).....	.14	.14	.14
Type "A," Full			
Carbon	.26	.30	.24
Manganese	.48	.50	.48
Chromium	1.00	1.00	1.00
Vanadium (contained).....	.18	.18	.18
Type "B"			
Carbon	.15	.18	.13
Manganese	.27	.30	.25
Chromium	.50	.50	.50
Vanadium (contained).....	.12	.12	.12
Type "C"			
Carbon	.17	.20	.15
Manganese	.35	.40	.35
Chromium	.80	.80	.80
Vanadium (contained).....	.16	.16	.16
Type "D," Regular			
Carbon	.41	.47	.38
Manganese	.80	.90	.80
Chromium	1.10	1.25	1.10
Vanadium (contained).....	.18	.18	.18
Type "D," Mild			
Carbon	.35	.40	.33
Manganese	.75	.85	.75
Chromium	1.00	1.10	1.00
Vanadium (contained).....	.16	.16	.16
Type "E"			
Carbon	.09	.13	....
Manganese	.20	.25	....
Chromium	.30	.30	....
Vanadium (contained).....	.12	.12	....

Type "F"			
Carbon .....	....	.09	....
Manganese .....	....	.20	....
Vanadium (contained).....	....	.12	....

Type "G"			
Carbon .....	....	.55	.60
Manganese .....	....	.60	.65
Chromium .....	....	1.00	1.10
Vanadium (contained).....	....	.18	.18

Type "H,"*			
Carbon .....	....	....	.85
Manganese .....	....	....	.45
Chromium .....	....	....	1.00
Vanadium (contained).....	....	....	.25

Type "J"			
(Steel Castings)			
Carbon	.25 to .30	....	....
Silicon	.25	....	....
Manganese	.50 to .60	....	....
Vanadium (contained).....	.20	....	....

Type "K"			
Carbon .....	....	....	.45
Manganese .....	....	....	.30
Chromium .....	....	....	1.00
Vanadium (contained).....	....	....	.20

REMARKS.

*Type "H" is specially intended for cutter work and would be modified, mainly as to its carbon percentage, in order to make it suitable for other work, such as saws, etc., while in some cases its Manganese content would be also lowered.

All steels to be as pure as possible from sulphur and phosphorus. The sulphur percentage may go to .035% without detriment.

With phosphorus at .02% the silicon may be 1% in types "A," "B," "C," and "S," and .15% in type "D."

With phosphorus at .03% the silicon should not exceed .07% in types "A," "B," "C," and "E," and .1% in type "D."

In type "F" the silicon should be as low as possible. In type "G" it may go up to .2% and in type "H" to .15% under normal conditions.

In these compositions the vanadium given in each case is that which should be contained in the steel.

From the earlier remarks it will be seen that an extra amount of vanadium must be added in order to cleanse the steel; this vanadium vanishes to slag in combination with the constituents from which it purges the steel.

Under normal conditions of good melting, it would be safe to assume that the finished metal in the furnace would contain rather less than .01% of nitrogen and about .02% of oxygen. To provide for the amount of nitrogen and oxygen, about .07% of vanadium (reckoned on the weight of the steel) would be required, but .10% of vanadium is quite commonly wanted to scavenge openhearth steel which has been well deoxidized by ordinary means.

In a steel of ideal properties it is a certainty that composition must play the leading "role," for though it is possible to manipulate a steel of bad composition

so that it fulfils a few of the requirements of a good steel, it is impossible by simple (or complex) "faking"—to use the term of Professor Arnold in this connection—to attain them all. Given the necessary composition, both the processes of manufacture and treatment of the product must be carefully carried out to ensure success, and in a steel of new composition these may deviate somewhat from routine practice as applied to ordinary steel. Hence something further is required after the matter of composition is settled.

HEAT TREATMENTS.

Based on Compositions given in Table.

No. 1. Anneal at 800°C for one or two hours, cooling slowly in air, in ashes, or even in the furnace, according to the nature of the piece, the cooling process being made to take place more slowly with smaller pieces, as such small pieces do not contain any body of heat.

No. 2. Quench from 900°C in oil and anneal ("led down" or "draw back") the quenched piece at 550°C for one-half to two hours according to size of piece. Cool in air.

No. 3. Quench from 900 to 950°C in oil and anneal at 360°C for one-quarter to one-half hour. Cool in air.

No. 4. Quench from 875°C in oil and draw back at 400 to 450°C. Cool in air.

No. 5. Quench from 850°C and draw back at 550°C. Cool in air.

No. 6. This number represents the special tool tempering treatment which is applied in ordinary circumstances to the nature of the same tool when made from ordinary steel.

No. 7. Case Hardening Process: The essential feature of case-hardening involves not only the production of a body having a hard outside, but of one which at the same time has a strong and tough core. Thus it will be seen that no tempering steel should be case hardened, for as the practically final process of case hardening involves a quenching treatment, such steel would become hard right through. Taking advantage of the comparatively slow transition of carbides through a vanadium ferrite, and of a strong nature of vanadium ferrite interspersed with well emulsified vanadium sorbite, and further of the comparatively tough nature of vanadium martensite, the type "E" Chrome-Vanadium steel is particularly suited to the case-hardening process. The raw steel is essentially a mild steel.

The best case-hardening process will be found by proceeding on the following lines:

The rough machined material is annealed, *irrespective of its softness*, in order to remove all strains imprisoned therein through the mechanical processes of forging or rolling. This is a very important item, as the first time the article is subjected to sufficient heat, these strains are liberated, and distortion ensues; consequently, if the piece has already been machined to dead size and the strains are liberated by means of the casing heat, the quenching process fixes this distortion

permanently. After such annealing, the article is machined to finished size and is packed in the carburizing material. Many good carburizing materials are to be found: bone, bone-dust, hydro-carbonated bone, good charred leather, and a mixture of charcoal and carbonate of baryta all being suitable. Great things are claimed for the last named, especially in France, on account of its declared regularity of penetration, but it would seem that its use is principally in the direction of the cementing of large articles, such as plates, etc. It is the consensus of opinion that the best carburizing agents are nitrogenous; nitrogen compounds probably assist the carburizing either by the promotion of secondary reactions, or as some contend, through their lowering action on the transformation point of iron. Small amounts of nitrogen, pure and simple, are absorbed or occluded from them by the iron to be cased but such nitrogen is expelled by the reheating preceding quenching. It is important that the carburizing material should be thoroughly dried, evenly sized and free from all admixture of earthy or metallic impurities. The luting of the box containing the packed articles should be done with *clay which is absolutely free from grease*. The box and its contents are then heated to 1000°C and kept there as long as may be necessary; it is impossible to fix any given time, as naturally this must be regulated from practical experience, taking into consideration the contour of the article to be cased, its size, and the depth of casing desired.

The box and its contents are allowed to cool, the articles removed, brushed and reheated in an atmosphere as non-oxidizing as possible, to 850°C, when they are plunged in clean cool water. The article thus quenched is thrown into hot oil and kept at a temperature of about 200°C to 250°C for some time in order to release some of the strains caused by quenching. This oil warming does not appreciably interfere with the surface hardness of case hardened machinery steels, but it relieves imprisoned strains very considerably.

Trials made on test bars of open-hearth basic steel of the type above shown showed the following typical figures—in the soft condition:

Elastic limit, lbs. per sq. in.	43.650
Tensile strength, lbs. per sq. in.	70.780
Elongation in 2"	31%
Reduction of area	74.8%

Bars of 1½ and 1¼" diameter were cleaned and cased as recommended. The case-hardened bars were subjected to load until the outer surface was cracked; the bars had then taken a very appreciable bend, although the case hardening had penetrated at least one millimeter. The bars were then broken; sharp corners of the case would easily scratch glass. The hard casing was next ground away and as soon as a portion was obtained sufficiently soft to be machined were turned down to the ordinary shaped tensile test-piece, and also to round rods about one-half inch diam-

eter. Tensile test of the actual cores showed the following figures:

Elastic limit, lbs. per sq. in.	81,000
Tensile strength, lbs. per sq. in. . .	103,000
Elongation in 2"	20%
Reduction of area	60%

In each case the machined half-inch rounds from the core bent double cold.

The dynamic figure under alternating impact was exceptionally high when the steel was in the soft con-

Shop, with the Reading of the Electric Resistance Pyrometer.

Black red (just visible)	About 500°C
Dull blood red	" 550°C
Warm blood red	" 600°C
Cherry red	" 700°C
Very full cherry red	" 800°C
Light red, merging from very clear cherry	850 to 900°C
Orange to light yellow	1000 to 1100°C

RESULTS OF SOME COMPARATIVE TESTS MADE ON ALL GRADES OF STEEL TO DETERMINE RELATIVE STRENGTHS AND PROPERTIES OF FATIGUE RESISTANCE.

THE RESULTS ON EACH STEEL ARE COLLECTIVELY COMBINED INTO A "QUALITY FIGURE"

No.	STEEL	HEAT TREATMENT	APPROXIMATE CHEMICAL ANALYSIS					STATIC FIGURES					DYNAMIC PES. AVER. QUANTITY PER AIN	PROCESS OF MANUFACTURE	REMARKS			
			C.	MN.	CR	NI.	V.	ELAS. LIMIT	TENSILE STRENGTH	RATIO EL. TO TENS.	EL. % RED. A	Dynamic PES. AVER. QUANTITY PER AIN						
ELASTIC LIMITS—30,000—60,000																		
1	Mild Vanadium Steel.....	Annealed	.11	.31			.19	32,120	54,400	59.0	44	0.60	1,111	2143	Open Hearth.....	Scrapped After Service.		
2	Old Boiler Plate.....	Raw	.24	.42				58,160	70,840	82.1	25	553	4	612	1901		Open Hearth.....	
3	Mild Carbon Steel.....	Annealed	.18	.40				39,460	60,650	65.1	35	0.62	6	871	2152	Open Hearth.....	Shafting Steel. Specially Selected.	
4	Mild Carbon Steel.....	O.T. 900-425	.18	.40				45,390	70,030	64.6	33	0.64	0	777	2258	Open Hearth.....		
5	Carbon Forging Steel.....	Annealed	.26	.28				43,010	61,850	69.5	34	0.63	4	1415	558	Open Hearth.....		
6	Carbon Forging Steel.....	O.T. 900-550	.26	.28				52,230	77,310	67.5	28	0.65	3	2175	4008	Open Hearth.....		
7	Vanadium Case Hardening Steel.....	Annealed	.15	.25		.30	.12	44,790	55,990	80.0	45	0.69	0	1958	6051	Open Hearth.....	Sliding Gear Steel.	
8	Chrome-Nickel Steel.....	Annealed	.36	.34		95.1	.70	56,520	81,370	69.5	32	0.68	5	978	3787	Crucible.....		
9	Carbon Steel Casting.....	Annealed	.18	.65				34,680	58,800	57.0	28	0.44	9	209	419	Acid Open Hearth.....		
10	Vanadium Steel Casting.....	Annealed	.19	.60				44,240	70,250	63.0	25	544	9	850	1671	Acid Open Hearth.....	Use for Car Wheels. (N B—High Carbon Steel)	
11	Cr.-Va.-Steel Casting.....	Annealed	.57	.68	.75		.16	52,330	92,900	56.3	16	0.20	5	656	704	Basic Open Hearth.....		
ELASTIC LIMITS—60,000—100,000																		
12	Nickel Forging Steel.....	Annealed	.21	.45		.3	.70	61,140	79,700	76.7	30	0.62	5	746	2851	Basic Open Hearth.....	Known as Type "A".	
13	Nickel Forging Steel.....	O.T. 900-550	.21	.45		.3	.70	77,140	98,470	78.3	25	0.65	3	664	3345	Basic Open Hearth.....		
14	Chrome-Vanadium Forging Steel.....	Annealed	.26	.50	.01		.16	61,920	92,900	66.6	25	0.57	3	1608	5706	Basic Open Hearth.....		
15	Carbon Spring Steel.....	Annealed	1.00	.30				63,800	125,000	51.0	8	5.15	2	1260	1222	Open Hearth.....	Known as Type "D". Imported Automobile Steel.	
16	Chrome-Vanadium Spring Steel.....	Annealed	.40	.74	.22		.19	67,530	100,000	67.1	26	0.61	7	1406	5858	Crucible.....		
17	Chrome-Nickel-Vanadium Steel.....	Annealed	.30	.27	.51	.3	.45	69,140	96,880	71.3	28	5.68	5	507	2402	Crucible.....		
18	Nickel-Vanadium Steel.....	Annealed	.24	.72		.3	.40	79,290	99,700	79.5	25	0.64	0	795	4048	Basic Open Hearth.....	Imported Automobile Steel. Type "D".	
19	Chrome-Nickel-Vanadium Steel.....	Annealed	.57	.27	.93	.2	.04	95,130	129,100	73.7	21	0.49	8	983	4559	Crucible.....		
20	Chrome-Nickel Steel.....	Tempered	.37	.34	.89	1.70		86,680	102,700	83.8	22	0.63	8	702	3855	Crucible.....		
ELASTIC LIMITS—100,000 and over.																		
21	Carbon Spring Steel.....	O.T. 900-450	1.00	.30				101,000	186,300	54.2	9	5.16	1	561	912	Open Hearth.....	Spring Temper.	
22	Chrome-Vanadium Spring Steel.....	O.T. 900-450	.40	.74	.22		.19	105,200	205,300	67.7	10	0.36	3	480	2403	Acid Open Hearth.....	Spring Temper Type "D".	
23	Chrome-Vanadium Forging Steel.....	O.T. 900-550	.40	.50	.01		.16	141,600	151,750	93.0	4	16	0.56	2	717	5705	Basic Open Hearth.....	Type "A" Crankshaft Tem-
24	Nickel-Vanadium Steel.....	O.T. 900-550	.24	.72		.3	.4	129,900	134,600	96.4	18	0.64	8	626	5270	Basic Open Hearth.....	per.	
25	Chrome-Nickel-Vanadium Steel.....	O.T. 900-550	.50	.27	.51	.3	.45	152,300	199,900	95.2	17	0.68	9	487	4309	Crucible.....	Imported Automobile Steel.	
26	Chrome-Vanadium Spring Steel.....	O.T. 900-550	.40	.74	.22		.19	183,400	187,600	97.7	14	0.50	6	1406	5858	Crucible.....	Type "D".	
27	Chrome-Nickel Steel.....	Tempered	.36	.34	.89	1.70		134,500	150,300	89.5	15	5.53	5	579	4166	Crucible.....		

O. T. = Oil Tempered.

NOTES.—Static tests made on samples $\frac{3}{8}$ " dia. x 2" long.

Dynamic tests made on Landgraf-Turner Alternating Impact Machine. (Old Form).

QUALITY FIGURE IS PRODUCT OF:

Elastic Limit Representing Useful Strength.

Reduction of Area Representing Static Ductility.

Dynamic Figure Representing Fatigue-Resisting Property.

Divided by One Million, or $\frac{E \times R \times A}{10^6}$ —Quality Figure.

Data Correct. W. L. TURNER, Eng'r of Tests. June, 1908.

dition; quality figures deduced from the static tests and the alternating impact tests on the Turner formula gave the high quality figure of approximately 6000, while the "core" gave a corresponding high quality figure.

In the foregoing, all temperatures quoted were determined by the electric pyrometer. The appended table gives the approximate color valuations of these temperatures in the diffused day-light of the ordinary shop. The temperatures generally enunciated in the pocketbooks as corresponding to various color shades should on no account be taken, as they are based on the fallacy that the specific heat of iron is constant for all temperatures, which is now known to be a grossly mistaken view.

APPROXIMATE CORRELATION OF COLOR TEMPERATURE As Viewed in the Diffused Daylight of the Ordinary

White	" 1200°C
Throwing off sparks, i. e., scintillating heat of fairly mild steel	" 1300°C
Melting point of mild steel, not determined by electric resistance	" 1520°C

TYPE "A."

This is perhaps the most adaptable of all types of vanadium steel. It has great static strength and ductility, with stupendous resistance to shock and fatigue.

Under trip hammer dies or drawing dies, it works comparably with soft open-hearth steel.

In drop forging, it flows readily in the die, withstands high temperatures without deterioration and takes a high finish.

TYPE "D."

This type is essentially suited for manufacture of

springs, and is also used for gears in constant mesh, rifle barrels, high tensile wire and similar work.

In springs it has double the co-efficient of safe working load of Carbon Spring Steel; it is easily "welded" and in service can be repeatedly overloaded without serious deterioration; it has an elastic limit of from 180,000 to 225,000 lbs. per sq. in., with tensile strength ranging from 190,000 to 250,000 lbs. Spring makers guarantee it to have three times the life of Carbon Steel springs.

A comparative test of Type "D" vs. Chrome-Nickel Spring Steel:

Both test pieces 25" long, of same width and gauge, with a 4" arc. In six plunges flat against the face of testing machine—

Type "D" Steel took permanent set of 3-16".

Chrome-Nickel Steel took permanent set of 3/4".

TYPE "E."

This type of steel is especially designed for case hardening. The essential features of good case hardening steel, the results obtainable from Type "E" case-hardened vanadium steel and the logical reasons involved, have already been fully dealt with.

Briefly epitomized, the advantages of Type "E" steel comprise (1) strong case, (2) powerful resistance to abrasion of such case, (3) close cohesion of such case to the softer core, (4) absence of "flaking away" or powdering away such case, (5) a core which is exceedingly ductile and at the same time has great strength and resistance to disintegration.

TYPE "G."

This type is designed for locomotive tires. It has high static strength, and withstands 1260 alternations before fracture under the alternating impact test, or more than double the number withstood by the regular grade of tire steel.

It is very homogeneous and machines quite readily; it combines superlative resistance to wear with an excellent adhesive surface—qualities of the utmost importance in a tire.

"TYPE "H."

This type of steel is intended especially for cutting tools, such as rotary cutters, etc. With some slight modifications as to Carbon and Manganese content, it is admirably adapted for use in manufacture of saw blades. It tempers accurately and evenly and although hard is extremely tough. Its especial advantages for saws is that the latter will not cramp in the cut, will not develop kinks; can be easily set without danger of fracturing the teeth; will retain the cutting edge more than twice as long as saws made from the regular Carbon Steel; and will hold the set and cut faster than any other saws.

TYPE "J."

This type of steel is designed expressly for castings, which are thereby rendered solid and more nearly perfect. It pours quietly and freely and is readily welded; it has approximately 25 per cent increased elastic limit and 15 per cent greater tensile strength than the regular Carbon steel casting; the ductility

is maintained and there is no impairment of the machining qualities.

Type "J" steel is extremely tough and close in structure. It withstands under the Turner formula about the same number of alternations as ordinary forged Steel of the same carbon content, *and twice that of the regular steel casting.*

This latter point is of supreme importance. Almost invariably the service failure of a casting is not traceable to any lack of original static strength and ductility but rather to the fact that it has deteriorated rapidly under the vibration and repeated stresses incidental to its practical usage. It is not claiming too much to say that vanadium steel castings approximate in "life" quality to forged Carbon Steel.

TYPE "K."

This type of steel is intended for the making of punches and dies, etc. It will not upset, is hard and tough and offers the ultimate resistance to crystallization attainable in steel of this "temper."

MACHINE FORGING AND WELDING QUALITIES.

The vanadium steels are readily forged and give no trouble in the fire. It is of course to be noted that the same precautions are to be observed in their initial heating as are accorded to any high-grade steel. With regard to drop-forging, all the vanadium steels flow readily in the dies and no trouble is experienced in the process, a fact which in this respect brings them into sharp contrast with some other alloy steels for which great merit is claimed as to mechanical attributes.

The ease with which the vanadium steels can be machined is a matter of deep interest to the practical engineer. Broadly speaking it will be sufficient to say that they are machined as easily as carbon steels of the same "temper."

Vanadium itself helps the welding qualities of iron, and this fact, coupled with its intensifying strengthening action (already alluded to), on such ingredients as are themselves inimical to successful welding. In considering this question of uniformity it should not be overlooked that: (1) As vanadium will perform its scavenging function first, the amount of vanadium that will remain in the steel will necessarily depend upon the degree to which the metal has been deoxidized before the vanadium has been added; (2) As detailed hereinbefore at some length, an enormous readjustment of static and dynamic equilibrium takes place at the calescence point and therefore the static properties of two identical vanadium steels, one of which has been finished or annealed above the calescence point and the other finished or annealed below the calescence point, must necessarily differ considerably. From this it is obvious that a conclusion of non-uniformity must not be hastily reached as the result of a simple test in one direction.

To these must be added the personal equation and those differences of shop practice which must exist in all steel making, so that degrees of limitation must necessarily be introduced.

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

HENRY WYSOR, Metallurgical Editor.

PUBLISHED MONTHLY BY

THE CHEMICAL ENGINEER PUBLISHING COMPANY

355 Dearborn Street, Chicago

Entered as Second Class Matter, Aug. 19, 1907, at the Post Office at Chicago, Illinois, March 3, 1879.

Subscription—United States, Cuba and Mexico \$2.00
Extra postage to Canada 25c a year; to foreign countries 50c a year.
Remittances may be made by check, draft, or money order in favor of
THE CHEMICAL ENGINEER PUBLISHING CO.

All matter connected with subscriptions or advertising should be sent to
THE CHEMICAL ENGINEER PUBLISHING CO., 355 Dearborn street, Chicago.
Anything intended for the Editorial Department should be sent directly to
the Editor, Richard K. Meade, Allentown National Bank Bldg., Allentown, Pa.

NOTES AND COMMENTS.

We desire to thank the International Bureau of American Republics for the loan of the cuts which were used to illustrate the article on "The Nitrate Deposits of Chile" which appeared in our July issue.

"Yellow Science."

The controversy between Secretary Ballinger of the Department of the Interior and Mr. Gifford Pinchot has of late furnished a great deal of copy for the newspaper writers of the country. As is usually the case, Secretary Ballinger has been the under dog, and, so far as public opinion goes, his motives have been placed entirely upon the ground of the conversation of private interests, rather than the carrying out of President Roosevelt's policy of the conservation of natural resources. We have had a great deal of yellow journalism on this latter subject. Magazines have been full of our national waste. Unfortunately it has not always stopped with the irresponsible part of the press, and some of our scientific journals have been almost as sensational as the evening papers. A number of chemists and engineers, who have been more largely contributors to our literature than to our actual advancement, have treated the matter to great length in a forensic rather than a practical way. Contrasted to these, were the addresses of such men as Dr. Douglas, Dr. Raymond and Mr. Baker at the meeting of four engineering societies.

The conservation commission as a whole, is not one which would upon careful consideration inspire very great confidence. While there are a number of gentlemen upon it who have done something towards making our natural resources last longer, there are a number of other gentlemen who have been equally prominent in getting as much out of nature as they could, or who have been connected as consulting engineers with corporations which have pursued this policy.

No one doubts for an instant that there is a great waste of our natural resources. At the same time, this waste has been greatly exaggerated. The average mine operator is getting all out of his mines that he can get economically, and the men in charge of our smelters are certainly not wasting fuel wan-

tonly. The government itself would hardly seem to be a very good teacher of the economic administration of business affairs. There are few industrial organizations which would exist long if conducted on the extravagant lines by which the government conducts its own affairs. The government officials may safely leave the matter of economy in production to the engineers and industrial men of the country. They can no more teach them to improve their methods of mining and burning coal or mining and smelting ores, than they can teach them how to make water flow uphill. It is absurd to think for an instant that they can.

Science can do a great deal towards effecting economies in production, but in the vast majority of cases, the men who are most likely to apply science to the solution of plant difficulties are not the scientists who are undertaking the problem from an academic side, but rather the man of general affairs who has the process daily under his observance.

Our loss annually in deaths, accidents and general carelessness could be much more easily lessened than can our waste of productions. We do not mean to belittle the conservation campaign. It is indeed a good plan to call attention to the fact that our national resources are not unlimited. At the same time, however, it is equally important to look at the matter in a fair minded manner, and dilute ourselves with no false hopes of help outside regular channels.

The controversy between Messrs. Ballinger and Pinchot over the water powers, of course brings up a very important point; namely, whether our water powers should be controlled by the government or not. If our government was conducting its affairs more economically, this would unquestionably be the best policy. The enormous amount of money, however, which has been used upon so-called river and harbor improvements, does not lead one to believe that our water powers would be greatly benefitted by being controlled by the government. It is all right in the academic scheme of political economy, but in practice, it has not worked out as we would wish. If congress would formulate some definite scheme of action and secure some competent engineers to carry out its plans, it would unquestionably be very much better for the government to control, or at least exercise some control over our water powers. In the helter skelter fashion however, in which government improvements are conducted at the present time, it is probably as well to let them pass into the hands of men who will generally develop them to their utmost capacity, thereby conserving our coal supply for smelting and metallurgical purposes.

A Practical "Dash to the Pole."

Some time ago the country was startled by the discovery, announced with proper display heads by all of the papers of our country, that an American had discovered the North Pole. This was followed a few days later by the equally vociferous announcement that another American had also planted his country's

flag at the Pole. Tucked away in an obscure corner of the papers which were so full of the exploits of these two explorers appeared a short paragraph stating that the wheat belt of Canada had been carried three hundred miles nearer to the North Pole. These figures were given by the Dominion's leading railroad officials.

Without belittling the dash and bravery of Dr. Cook and Commander Peary, which of these two exploits means the most to humanity:—the journey through snow and ice to a section of the world which can never be of any value to human kind, or the plodding "dash" of the Canadian farmer, which has made available many millions of square miles of land for the raising of wheat for the feeding of the world's growing population? Do we not sometimes let the mole-hill hide the mountain and applaud the shadow for the substance.

BOOK REVIEWS.

TABLES OF PROPERTIES OF OVER FIFTEEN HUNDRED COMMON INORGANIC SUBSTANCES. By Wilhelm Segerblom, A. B., Instructor in Chemistry at Phillips Exeter Academy, 8 vo. Cloth. 144 pages. Price \$2.00. Exeter Book Publishing Co., Exeter, N. H. 1909.

This little book is designed to be of assistance to students of quantitative analysis. It contains, however, a great deal of information which would be of interest to the chemist whose library is small. The book, as indicated by the title, consists largely of tables giving the principal properties of such substances as may be reasonably looked for in a course of Quantitative Analysis. No attempt has been made to make the work complete with respect to every known salt. The tables are arranged with the metals grouped as they are by various reagents in quantitative analysis. The metal itself is placed at the head of the column and the salts are placed under them in alphabetical order. The name of the acid radical is placed on the margin. The information includes color, luster, crystalline form, deliquescence, efflorescence, stability in air, action on test papers, melting point, behavior when heated, solubility in water, alcohol and acid, and any other properties that are characteristic of the substance in hand. For convenience, the chemical names and symbols and the common names are also given. The tables are arranged so that the salt may be readily found. They are compact and substantially free from errors.

ASPHALTS, THEIR SOURCES AND UTILIZATIONS. By T. Hugh Boorman, Civil Engineer and Asphalt Expert. 8 vo. Cloth. Illustrated. 168 pages. Price \$3.00. William T. Comstock, New York, 1909.

This book on asphalts is the outcome of a series of articles that appeared some time ago in the *Architects' and Builders' Magazine*. The numbers containing these articles ran out and the continual call for them necessitated the issuing of them in book form. The

author states that the book is the result of thirty-six years of active life in the asphalt industry. It opens with a short historical sketch of the discovery and the earlier use of asphalt. This is followed by a chapter upon various asphalt materials, including Trinidad and Venezuelan asphalts. These chapters are followed by a chapter on the developments of the asphalt industry up to 1903, which is from the pen of Wm. H. Delano and which appeared as a paper before the Institution of Civil Engineers. Other chapters are devoted to asphalt in building construction, the employment of bituminous materials to the laying of dust on macadam roads, to more lasting methods of waterproofing the surface of macadam roads, the application of asphaltic oils, municipal asphalt plants, asphalt waterproofing, asphalt in roofing, asphalt manufacture, and asphalt machinery. On the whole, the book contains a great deal of valuable information upon asphalts which will be of much use to the engineer and chemist. At the same time, it could unquestionably be very much improved by a better arrangement of the material.

REINFORCED CONCRETE IN EUROPE. By Albert Ladd Colby. 8 vo. Cloth. 260 pages. Price \$3.00. Chemical Publishing Co., Easton, Pa. 1909.

This little book is a compilation of information on reinforced concrete construction in Great Britain and on the Continent, collected during 1908, chiefly by personal interviews with the leading authorities in each country, and originally prepared as a report to a client. In response to numerous requests, permission has been given, happily for those interested in reinforced concrete, to reprint the report for sale as a book. The theoretical branches of the subject, including rules for calculation, are only briefly referred to, owing to the fact that there are elaborate treatises on this subject which treat very fully with these matters. Such practical branches of the subject, however, as economy and proof of the endurance of reinforced concrete construction, the systems used abroad, the specifications for the cement used, the ingredients and the mixing of the concrete and the rules governing construction are fully treated of. In addition to this a large amount of other information of a practical nature has been given, such as a list and description of foreign government and private testing stations, technical institutions, associations, and committees who have endorsed reinforced concrete as a material for construction or who have adopted resolutions, specifications or rules relating thereto. The book includes with a bibliography on reinforced concrete and cement, which includes books printed in England, France, Germany, Austria and the United States, arranged alphabetically by authors and titles, including the date and price; and of journals and periodicals devoted entirely or prominently to these subjects, including in each case the name of the journal, the address and the annual subscription.

Being, as it is, a report, the material has been necessarily greatly condensed. The book is a noteworthy

contribution to the literature of reinforced concrete and will no doubt prove of great assistance and value to those who are desirous of posting themselves on reinforced concrete abroad. While as Urban said, the descriptions are brief, the information contained is very voluminous and is placed in such form that it can easily be followed up by more detailed information from various reports and books.

RECENT PATENTS.

The following patents relating to industrial and engineering chemistry are reported by C. L. Parker, solicitor of chemical patents, McGill Building, 908 G Street, N. W., Washington, D. C.

929,687. *Clad Metal and Process of Producing the Same.* John F. Monnot, New York, N. Y. August 3, 1909.

The process consists in producing clad metal objects comprising unlike metals weld-united by casting molten bodies of unlike metals into contact with opposite surfaces of a separator of material capable of weld-uniting with both the metals so cast, and progressively cleaning one or both said surfaces by the action thereon of a deep layer of molten flux containing oxid-dissolving material.

929,726. *Method of Obtaining Purified Ammonia-Gas from Ammonia Liquors.* Charles M. Stine, Chester, Pa. Aug. 3, 1909.

The method consists in forcing a current of air through ammoniacal liquor initially at atmospheric temperature and then gradually heating the same.

929,845. *Art of Improving the Odor of Vegetable Oils.* John H. Filbert, Baltimore, Md. Aug. 3, 1909.

The process consists of heating the vegetable oil in a suitable vessel; mixing or immersing in the oil aimal cracking; then filtering the oil to remove the said cracking.

929,962. *Manufacture of Lead Arsenate.* Ellerslie E. Luther and William H. Volek, Watsonville, Cal. Aug. 3, 1909.

The process consists in roasting combining weights of white arsenic and lead compound in the presence of oxygen.

929,963. *Disinfecting Composition.* Arthur W. Lyda and William W. Curbison, New Castle, Pa. Aug. 3, 1909.

The composition consists of menthol, thymol, oil of eucalyptus, oil of sandalwood, oil of lavender, carbolic acid, paraformaldehyde, cumarin, and boric acid.

930,028. *Method of Reducing Ores.* Frederick M. Becket, Niagara Falls, N. Y. Aug. 3, 1909.

The method consists in reducing ores of refractory metals, by smelting a charge containing such ore and calcium borid.

930,030. *Compound for Eliminating Noxious Fumes when Exploding Nitroglycerin.* Frank P. Bettanin, Bessemer, Mich. Aug. 3, 1909.

The compound consists of dynamite, potassium chlorate and oil of pine combined in about the proportions stated.

930,057. *Process for Making White Lead.* John A. Erbslow, Los Angeles, Cal. Aug. 3, 1909.

The process consists in causing lead in divided condition to move alternately into a body of water and into atmospheric air above the body of water, causing the pieces of lead in this motion to rub on one another, and in their descent from the air into the water, to carry air into the body of water to produce a foam containing white lead, drawing off said foam and drying the foam to obtain the white lead therefrom.

930,274. *Method of Treating Wood During Distillation.* Howard W. Doughty, Amherst, Mass. Aug. 3, 1909.

The process consists in hydrolizing the cellulose with sulfuric acid and steam under pressure and driving off the volatile oils by the same heat, treating the solid residue with

sodium hydroxid and after filtering bringing the acid and alkali solutions together in equivalent proportions, whereby the sulfuric acid is neutralized and the resinous acids are precipitated, then filtering, fermenting the filtrate and distilling off the alcohol.

930,344. *Process of Treating Titaniferous Iron Ores.* Wilhelm Borchers, Aix-la-Chapelle, Germany, Aug. 10, 1909.

The process consists in initially smelting iron ores in presence of carbon directly, drawing off the crude iron, reducing the slag produced during the smelting operation to a reducing agent by raising its temperature and adding carbon, and utilizing said reducing agent for reducing subsequent charges of titaniferous iron-ores.

930,376. *Method of Treating Aluminous Materials.* Aldus C. Higgins, Worcester, Mass. Aug. 10, 1909.

The method consists in subjecting aluminous materials, suitable subdivided, to heat under oxidizing conditions, and thereby oxidizing impurities therein, then adding a bonding agent and forming articles from the prepared material.

930,442. *Method of Making Acids.* John L. Tufts, Boston, Mass. Aug. 10, 1909.

The method consists in commingling a chloride and an acid body capable of decomposing the same, working the mixture under the influence of heat until portions of the same become solid, continuously displacing such solid portions from the remaining pasty portions, continuing the working of said pasty portions and subjecting the displaced solid portions to the action of heat.

930,471. *Process of Manufacturing Sulphuric Acid.* William Hallock, New York, N. Y. Aug. 10, 1909.

The method consists in putting sulphurous oxide (SO₂) and oxygen in an ionized condition, whereby the SO₂ is oxidized to SO₃.

930,524. *Composition Roofing and Process for Producing It.* William A. Biles, Birmingham, Ala. Aug. 10, 1909.

The composition consists of twenty parts of magnesite, seventy-five parts of crushed slate, five parts of resin, and chlorid or magnesium in quantity equal to from twenty to twenty-five per cent by weight of the other elements in the composition.

930,549. *Insecticide.* Frank X. Lechner, Chicago, Ill. Aug. 10, 1909.

The composition consists of benzin, one gallon; pole root, one ounce; slum, one ounce, and red pepper two and one-half ounces, substantially as described.

930,570. *Igniting Composition for Matches.* Louis Stange, Aachen, Germany. Aug. 10, 1909.

The composition for matches consists of a solid inorganic oxidizing salt, powdered glass, sulphur, antimony sulphide, glue, and diazobenzene sulphonic acid.

930,666. *Process of Treating Ores.* Paul L. T. Herault, La Prax, France. Aug. 10, 1909.

The process consists in treating copper ore containing sulphur and iron by feeding it into an electric furnace and fusing it therein and simultaneously injecting oxygen in sufficient quantity to oxidize a large part of the sulphur and iron, and to leave only a black copper melt with a slag of gangue and iron.

930,697. *Waterproof Cement and Method of Making the Same.* Jacob F. Schoellkopf, Buffalo, N. Y. Aug. 10, 1909.

The cement comprises a mineral cement and an insoluble resin salt uncombined with material foreign to the base of said salt.

930,713. *Butter Making Process.* William W. Wygal and Calvin L. Burgess, Bluefield, W. Va. Aug. 10, 1909.

The process consists in placing a quantity of butter in a quantity of milk and simultaneously subjecting the mass to the action of heat, whereby through the medium of the milk, the butter is brought to the proper condition for emulsification with the milk, upon agitation of the entire mass

930,723. *Process of Forming Electric-Incandescent-Lamp Filaments.* Werner von Bolton, Charlottenburg, and Felix Hartman, Berlin, Germany. Aug. 10, 1909.

The process consists in inserting into a tube of ductile metal a tube of another ductile metal, inserting refractory metal powder into the inner tube, and subsequently working the tubes and the refractory metal powder into filamentary form.

930,764. *Method of Treating Iron Ore.* John T. Jones, Iron Mountain, Mich. Aug. 10, 1909.

The method consists in mixing carbonaceous material therewith, then advancing the mixture through a highly heated non-oxidizing atmosphere, to consume the carbonaceous material and support its combustion with oxygen from the ore, thus reducing the ore, then advancing the reduced mass through a non-oxidizing atmosphere of gradually-increasing temperature approximating without reaching the melting point of the slag constituents.

930,777. *Plastic Composition.* Joseph H. Mills, Richmond, Ind. Aug. 10, 1909.

The composition comprises resinous matter, a drying oil and a finely reduced cereal.

930,801. *Method of Manufacturing a Porous Material.* Hermann Senn, Szeszakowa, and David Kluger, Trselonia, Austria-Hungary. Aug. 10, 1909.

The method consists in calcining slate containing about 10 per cent of organic substances, to a heat of about 1,200 degrees C., whereby the material swells and a cellular structure is obtained, as insulating and filtering material being produced.

930,815. *Electrolyte.* Abraham Van Winkle, Newark, N. J. Aug. 10, 1909.

The electrolyte comprises a solution containing a fluorine salt of zinc and a small quantity of gelatin.

930,874. *Cellulose Substitute.* Oscar Muller, Cologne, Germany. Aug. 10, 1909.

The composition comprises cotton seed shells from which the binding materials and cotton fibers have been eliminated.

930,965. *Cleansing Fluid.* Nancy A. Hutchins, Chicago, Ill. Aug. 10, 1909.

The fluid consists of raw linseed oil, distilled water and silicate of soda, substantially in the proportions of one gallon of the oil, five gallons of water and four pounds of the soda, said ingredients or materials being thoroughly intermingled.

930,968. *Process of Obtaining Pure Metallic Copper from a Solution of a Salt of Copper.* Lucien Juman, Paris, France. Aug. 10, 1909.

The process consists in subjecting a copper containing solutions to heat and pressure, in the presence of a suitable quantity of wood used in any form, such as sawdust, shavings, waste wood and the like, and in putting the apparatus in which the reduction is effected, in communication with a space filled with some absorbent of carbon dioxide, such as lime and the like.

930,976. *Composition of Matter.* Samuel A. Leavitt, Gorham, N. H. Aug. 10, 1909.

This is an expansile acid-proof cement for lining digesters or the like, consisting of litharge, quartz, calcined plaster and lamp black, all brought to a plastic condition by the admixture of glycerin.

931,015. *Insulating Composition.* MinDelin McGerry, Kalamazoo, Mich. Aug. 10, 1909.

The composition consists of asbestos pulp, slippery elm, a vegetable acid, glue, starch and water.

931,027. *Baking Powder.* Wallace A. Beatty, New York, N. Y. Aug. 17, 1909.

A baking powder containing the following ingredients in approximately the proportions named, by weight: An amino acid, 37.5 per cent; sodium bicarbonate, 25 per cent, and an inert food product as a filler or diluent, 37.5 per cent.

931,081. *Process of Preparing Storage-Battery Elements.* David P. Perry, Chicago, Ill. Aug. 17, 1909.

The process consists in dissolving copper and cadmium together, precipitating the hydrates of the metals thus dissolved, converting the same to their oxides and subsequently securing the oxides thus obtained in a suitable support.

931,092. *Electrolytic Production of Magnesium.* George O. Seward and Franz von Kugelgen, Holcombs Rock, Va. Aug. 17, 1909.

The magnesium is obtained by electrolyzing a fused bath of magnesium chlorid, potassium chlorid and barium chlorid.

931,121. *Process of Extracting Rubber-Like Gum from Its Vegetable Sources.* Felix H. Humick, Roselle, N. J. Aug. 17, 1909.

The process consists in softening the source of the rubber by subjecting it to the action of steam in an inclosure; mechanically finely dividing the softened source, subjecting the finely divided source to the action of a series of independently moving, hard-surfaced bodies in an inclosure containing an excess of water, immersing the source in a body of water until the gum floats and the heavier impurities sink, then subjecting the gum to a high degree of heat and aqueous vapor under pressure in an inclosure.

931,310. *Method of Manufacturing Goods of Rubber Elbonite or Vulcanite.* Otto C. Immisch, Finchley, England, Aug. 17, 1909.

The process consists in manufacturing articles from waste rubber, vulcanite or the like by reducing the material to be treated to a suitable state of disintegration, adding thereto a quantity of caejput oil, then subjecting the mass under slight pressure in a mold to a temperature from 225° to 280° Fah., in order to volatilize the oil and then compressing and cooling the mass.

931,324. *Composition for Coating Receptacles.* William R. Long, St. Louis, Mo. Aug. 17, 1909.

This is a composition for rendering fibre receptacles impervious to oils and the like and which is non-cracking, consisting of glucose and converted flour containing gluten.

931,335. *Paint and Varnish Remover.* Leo Ornstein, Brooklyn, N. Y. Aug. 17, 1909.

The remover consists of anilin, ether, ethyl alcohol and lanolin.

931,433. *Silk Product and Process for the Treatment of Silk.* Jacob Knip, Paterson, N. J. Aug. 17, 1909.

The process is for the treatment of silk to obtain a weighted silk of a uniform blue black color, and consists in weighting the silk, then subjecting it to a bath of pyrolignite of iron and thereafter to a bath containing tannin.

931,498. *Process for the Treatment of Steels for Industrial Purposes.* Eugene Schneider, Le Creusot, France, Aug. 17, 1909.

The process consists in heating the metal to a temperature above the critical point in heating, cooling the same to about 250° C. above the critical point in cooling and then retarding the cooling of the same by maintaining for a period the temperature of the metal approximately at said last-named critical point for the purpose described.

931,515. *Method of Treating Corrosive Gaseous Fumes or Smoke.* Clarence B. Sprague, Salt Lake City, Utah. Aug. 17, 1909.

The method consists in introducing into the smoke on its way from the furnace a pulverulent neutralizing agent which is held in suspension in the smoke and unites with the corrosive compounds therein to form non-corrosive compounds, and thereafter filtering the smoke to remove the fume.

931,519. *Composition for Removing Dried Paint.* Varnish and Lac. Robert G. Stewart, Newburgh, N. Y. Aug. 17, 1909.

The composition comprises a mixture of 200 parts acetic ether, 30 parts anilin and 1 part paraffin oil.

The Chemical Engineer

PUBLISHED BY

The Chemical Engineer Publishing Co., 355 Dearborn St., Chicago

Vol. X.

NOVEMBER, 1909.

No. 5.

ANALYTICAL CONTROL OF BOILER FIRING BY MEANS OF AUTOMATIC ANALYSERS.*

By G. D. CEDERBORG.

Chemical Engineer, Denver, Colo.

The raw materials of combustion are fuel and air, one just as important as the other. But the fuel costs money, while the air is the cheapest material on earth. Naturally more attention is given to a raw material that is expensive than to one that is got for nothing. The air used for combustion is, however, never so cheap that you can afford to use it too lavishly, for it is the source of the greatest waste product of heat manufacture, viz., the hot stack gases. Other waste products are ashes, loss through radiation, etc.

The analytical control of combustion includes the determination as to quality and quantity of the following items:

Raw materials: Fuel, air.

Products. Useful heat, stack gases, ashes, radiation.

Of these items fuel is the one for which we pay out money, useful heat is the one from which we derive a benefit. The waste products are where we lose our money.

For an effective control we need to know the quantity fuel consumed as well as the number of heat units it is capable of developing. It is valuable, also, to know the chemical composition of the fuel. The air we get of uniform quality from mother nature and it requires, therefore, no analysis. We can always assume that the air is composed of 20.8 per cent oxygen and 79.2 per cent nitrogen, but it is absolutely necessary to know the quantity of air that we use.

Furthermore, we must know the quantity of heat that we have been able to make useful. If we can do so directly, as for instance, by measuring feed water, well and good, otherwise we must arrive at this figure in a round about way by means of the losses.

It is well known that the greatest part of the heat loss is in the stack gases, either as sensible heat or latent as unburned combustible gases. In order to

reduce, as far as possible, the loss through sensible heat we must produce as little stack gases as possible and send them out as cool as possible.

When we burn a ton of coal on the grate of a boiler we produce a certain number of heat units which are taken up by the gases rushing through the fire. All this heat is not worth a cent outside the shell of the boiler; we must get it inside the plate, at least as much of it as is possible.

Would it not be possible to construct a boiler that would absorb all the sensible heat contained in the flue gases? Theoretically, yes. We can conceive an ideal boiler built on the principle of two contrary currents. The cool feed water meeting gases of nearly the same temperature, the water gradually increasing in temperature until near the entrance of the hot gases steam is generated. Such an exchange of heat between two mediums is not unusual in the technical world. All boilers in practical use are, however, built to contain water of practically uniform temperature, and thus the boiler cannot cool down the gases more than to this temperature, and even this is not practicable. If we want to take more heat out of the flue gases for the heating of feed water we must put in an economizer which is a unit in itself.

Every boiler has a limit of heat absorption depending on the condition of the heating surfaces. Scale on the inside and soot on the outside of the tubes and shell will impair the heat absorbing properties of the boiler considerably. The scale proposition is always a serious matter in all boiler plants working with impure feed water. The purification of feed water is one of the most important problems of the technical chemist. Soot can be eliminated by frequent cleaning, by smokeless combustion, or in the case of economizers, by mechanical scraping devices.

Given a boiler with heating surfaces clean inside and out, what can be done to make a greater number of heat units travel from the flue gases to the water? Just one thing, increase the driving force behind these heat units; in other words, increase the difference between the temperatures of the gases and the water, increase the initial temperature. The stack temperature is dependent much more on the conditions of the heating surfaces than on the initial temperature. You can increase the furnace temperature 500-800 degrees Fahrenheit and you will hardly notice any

*Part of a Paper read before the Colorado Section, Western Society of Chemists and Metallurgists.

rise of stack temperature at all. Many engineers claim that the hotter the furnace the cooler the stack gases. This seems to me, however, to say the least, mysterious. In most cases I have found a slight rise, and when I did not it generally was a case of very leaky boiler settings; and then you never can tell much about the stack temperature anyway. The engineers of the Geological Survey found that a rise of furnace temperature is always accompanied by a slight rise of stack temperature.

Be that as it may, one thing is sure, you gain more in increased heat absorption with a high initial temperature than you lose by the slight rise of stack temperature.

The initial temperature is dependent solely on the proportion between fuel and air. As all the heat units generated except those absorbed by the brickwork must be taken up by the air rushing through the fire, these heat units will be able to impart a much higher temperature to a small quantity of air than to a large one.

It might then be supposed that all that is necessary to get a high efficiency is to increase the furnace temperature as much as possible. It is not quite as simple as that. You should try to increase the furnace temperature and produce a gas rich in CO_2 , but you should do it judiciously, because when you try to avoid the Scylla of excessive draft you stumble against the Charybdis of incomplete combustion.

Incomplete combustion is a chapter of itself in the story of fuel economy. It is the greatest obstacle in the path of the fuel technologist; how to avoid it is the most serious problem of the furnace maker.

In the problem of fuel economy you have two unknown quantities; loss through air excess in your x , loss through incomplete combustion is your y . The equation you are called upon to solve is:

$$x + y = \text{minimum.}$$

One equation with two unknown quantities. In order to solve it you must find one more relation between x and y . This is best found through their common relation to the per cent of CO_2 in the gas.

The per cent of CO_2 has a certain relation to the loss through excess air and also a certain relation to the loss through incomplete combustion. The experimenters of the Geological Survey found that the sum of these two losses was lowest, that is the efficiency at its maximum, when the CO_2 was 9%; but they also admit that they had a leakage of 20-30%. The correct figure would, therefore, be about 12%. Others claim that a higher efficiency can be obtained at a higher per cent of CO_2 . Be that as it may, there exists for every boiler plant running under normal conditions and with a fuel of uniform grade, a certain per cent of CO_2 , at which it will work at its fullest efficiency. This can be determined accurately only by experimenting, but when this figure is found, it is the business of the man in charge to keep the per cent of CO_2 there and keep it steady. It will not do to run one

minute with 4% CO_2 and another minute with 20%. Since you would lose considerably in both cases, the total loss would be much more than the average between the two figures would seem to indicate. That is why a large number of individual analyses will give a much better control over the economy of the firing, than the analysis of an average sample drawn from the flues during a long period.

Suppose that you have drawn off an average sample that analyzes, for example:

CO_2	10.0%
CO	0.5%
O_2	8.0%

You may wonder why there is any CO with such a great excess of oxygen. The explanation is simple: 0.5% CO and 8% O_2 cannot exist together in any ordinary boiler furnace. At no time during the firing was there a gas of this composition, but, perhaps, at some time there was a gas of about the following composition:

CO_2	16.0%
CO	1.0
O_2	1.0

The low sum of CO_2 , O_2 and $\frac{1}{2}\text{CO}$ indicates a great unknown loss through unburnt hydrocarbons. At other times the gas was, perhaps, something like this:

CO_2	4.0%
CO	0.0
O_2	15.0

In the former case there was a great loss through incomplete combustion; in the latter case an enormous loss through excess air. The remedy is not to increase the average air supply in order to burn the CO. The remedy is to increase the air at times and decrease it at times, in short, to produce a uniform gas. If the gas does not contain more than 10% CO_2 , there need be no CO at all if the firing is even. It pays much better to produce a uniform gas of moderate per cent CO_2 than an uneven gas averaging a higher per cent CO_2 . A straight curve on the chart of a CO_2 recorder is a map of the path of efficiency.

The value of producing a uniform gas is emphasized by the excellent efficiencies obtained by the use of certain mechanical stokers, that are designed in such a way that they automatically keep a correct relation between fuel and air. A CO_2 record from such a plant varies but little. A CO_2 record from any ordinary hand fired plant in which no particular attention is given to the production of a uniform gas, is very different. Very often one finds differences of 8% and more. A skillful fireman will, however, soon learn to remedy this evil through a judicious manipulation of damper, a well adjusted admittance of air above the grate, as well as a careful attention to the condition of the fire bed. I know a fireman that could keep the gas from a hand fired boiler furnace steadily between 11 and 13% CO_2 . Such a gas does not contain any appreciable amount of CO, and in the heat balance

calculated from the analysis of such a gas, the item of unknown losses will be small.

You will often hear the statement that our western lignite coal cannot be fired without a considerable loss through incomplete combustion or else a very large amount of excess air. Though I have, as yet, insufficient experience with the western coals to be able to speak with much authority in this matter, I dare say that if the lignite is fired in a manner suitable to its peculiar properties, there is no reason why this fuel should not be burned with as perfect economy as any other coal.

When you burn a coal containing very little volatile matter, the condition of the fire is practically constant, the combustion taking place largely in the fire-bed itself. Only a comparatively small amount of secondary air is necessary to burn the CO rising from the fire. In the case of firing a fuel containing large amount of volatile matter, such as our western coals the case is a different one. When a fresh supply of coal is thrown on the fire a large amount of volatile matter is given off at once, and what really is needed at that moment is a furnace built for the combustion of gaseous fuel. As soon as most of the volatile hydrocarbons are driven off, you again have the case of burning solid fuel.

In building a furnace for gaseous fuel we always strive to provide the right amount of air in the right place. Wherever there is an inlet for gas there must be an inlet for air so placed that the mixing of gas and air is facilitated. Such a mixing of air and the combustible gas is not so easily accomplished in a common boiler furnace. Generally the only way of admitting secondary air is through a star-shaped valve in the fire door, which generally is altogether inadequate for the large amount of air necessary after the firing of a fresh charge of high volatile coal. The door may be left slightly open after firing, but this gives too much air on one side and too little on the other.

The velocity of the gas is so great in the furnace itself, that unless the air is well distributed, very little mixing will occur here. Therefore a large combustion chamber should be provided, so built that the gas will be made to whirl around. The more motion there is in the combustion chamber, the more whirling and eddying, the more chance for the atoms of carbon or hydrogen to find their complementary atoms of oxygen. Every chemist knows that certain reactions can be considerably accelerated by stirring. What the stirring does not do, time will; therefore, the combustion chamber should be large so as to leave the longest possible time for the combustion to take place. The stirring of the gas is easily accomplished by means of baffle walls in the combustion chamber. There is, however, one serious objection to these baffle walls, viz., the cost of draft. I will come back to this matter later.

Taking everything in consideration it is very difficult to fire a high-volatile coal properly by hand, and

in the inability of the average fireman to produce a uniform stack gas with high-volatile coal is to be found the reason why the combustion of this fuel generally is accompanied by high losses either through incomplete combustion or through excess of air or both. The study of this matter is very important and a task as much for the chemist as for the mechanical engineer.

The problem is simpler when mechanical stoking is employed. The fuel is fed more or less continuously, the volatile matter is, therefore, given off continuously, and the supply of secondary air needs very little regulating. The problem is simple but has as many variations as there are different designs of mechanical stokers. Some have grates and others have none; in some, the fuel lies stationary on a moving grate, in others the fuel is moved over a stationary grate; still others imitate the hand firing in throwing the fuel on the grate. All have their frailties and need careful attention to give the best result. From the chemical point of view, the principal demand on a mechanical stoker is a correct distribution of fuel and air. There must be no false air in one place and piling up of fuel in another, which is a common occurrence with this device, which, be it ever so perfect mechanically, still lacks the brain of the intelligent fireman. For this reason, and also because the mechanically fired furnace never can be under such close surveillance as the hand fired one, the chemical control is more important in the former case than in the latter. Moreover, on account of the continuous feeding of the fuel, the result is more easily attained.

So far I have spoken only of chemical control as a means for attaining a high technical efficiency of the boiler. It is, however, not technical efficiency merely that is demanded of a boiler plant; it is not the technical efficiency that pays the steam engineer's salary, it is the economical efficiency. If the technical efficiency is measured by pounds of steam produced per pound of fuel, the economical efficiency is measured by pounds of steam produced per dollar expended. The boiler plant is an expensive apparatus and there is often more money in raising the capacity of boilers to the highest possible degree than to strive for a high technical efficiency alone.

It is, however, seldom necessary to impair the efficiency of a plant in order to attain a high capacity. As a general rule efficiency and capacity rise together, and with the content of CO₂ in the gas. The capacity rises faster than the efficiency, especially when the CO₂ is high. The Geological Survey has done some interesting work along this line.

The capacity of a boiler is proportional to the quantity of gases drawn over the heating surface and also to the difference between the temperature of the gas and the water. Therefore, a high initial temperature, in other words, a high per cent CO₂ is necessary as well as a high rate of combustion.

In order to move an increased quantity of gas over

the heating surfaces, an increased draft is the first condition. Therefore, in many places where a boiler plant has to work constantly or intermittently at a high capacity, artificial draft is used. In the last few years there has been a tendency to equip more and more boiler plants with forced draft. The gain to be attained in this way is a higher economical efficiency of the plant through increased capacity or through burning cheaper fuel. The vast majority of boiler plants, however, still work with natural draft which, after all, is the simplest, and in most cases, the cheapest way.

Even the natural draft, however, is no free gift of heaven. Smoke stacks, especially if they are high, are expensive affairs. A smoke stack is an elevating machine handling an enormous amount of material. For every ton of coal burned the stack has to elevate at least 15 to 20 tons of gaseous material. It should, therefore, be nursed just as carefully as any other piece of machinery. Its power should be kept unimpaired, and it should not be called upon to perform a lot of extra work in the shape of elevating excess air and leakage. The power that moves the gases in the stack is the difference between the specific gravity of the outside atmosphere and that of the gases, and depends for any given stack almost entirely on the temperature of the gases.

When the gases have passed the last foot of heating surface of the boiler they still have a duty to perform, to furnish the draft power of the stack. It is, therefore, wasteful to permit any extra air to leak into the gases lowering the temperature of the same.

In almost any boiler plant where no special attention is given to the matter of preventing leakage through the settings, you will find that the stack gases have been diluted from 20 to 50% before they are allowed to escape to the stack. A leakage of 50% by weight will lower the temperature of the stack gases, say from 570 to 370 degrees Fahrenheit, causing the difference between the specific gravity of the air and that of the gases to drop about 18%, at the same time increasing the bulk of the gases about 22%, thus not only lessening the draft power, but also increasing the load this power has to work against.

The amount of leakage is easily found by analyzing the gas simultaneously at two points, for example, in the combustion chamber and at the base of the stack. It is a matter of surprise how much air will leak through apparently harmless cracks and even through the solid brick itself. In many well managed boiler plants it is therefore a rule to enclose all the brick work in a shell of sheet iron, in others it is considered sufficient to close up all cracks and fill the pores of the brick with some kind of paint. At all events it is cheaper to make the settings tight than to add 20 or 50 feet to the height of the stack.

It is always well in all boiler plants to have a good reserve supply of draft. If the boiler has to be forced to a high capacity, it requires draft; if smaller fuel

has to be burnt, it requires draft; if it is desired to produce a more complete combustion by means of baffling in the combustion chamber, it requires draft. With a good damper the fireman has it in his power to use just as much draft as is necessary for the moment. The damper is the principal tool of the skillful fireman and a money saving device altogether too much neglected.

Having pointed out the need for analytical control of combustion, I will proceed to show how such control can be effected.

There are two ways to arrange the details of analytical control; either by drawing off an average sample of gas by the simple means of allowing water to trickle from one vessel to another, and then making an analysis of the collected gas, or by installing an apparatus which will make a more or less continuous record of one of the constituents of the gas. The former method is correct for a boiler trial, but as I pointed out before, it is not well adapted to the daily routine. If used for this purpose, a complete analysis of the gas is absolutely necessary each time, otherwise there is no way of knowing whether at some time during the period of collection the furnace was run in such a manner that incomplete combustion occurred. A complete gas analysis is a tedious procedure and not very reliable with the commonly used apparatus, such as the Orsat. Generally all that is considered necessary is the determination of CO_2 , CO and O. The CO_2 and O are easily and accurately determined, but the estimation of CO is generally of very little value. The absorption of this gas is slow and is seldom complete; the absorbing liquid must be changed very often, and the least carelessness in the determination of O will result in too high a result for CO. These objections apply with greater force when it is remembered that in average samples of gas, the CO is the most important constituent to be determined, as it is the sole index of incomplete combustion. The small amount of CO present is, in itself, insignificant, but it may mean a serious loss of unburned hydrocarbons and hydrogen, indeterminable in the common methods of gas analysis. As I pointed out before, in a momentary gas sample there is always a constant relation between the CO_2 and the products of incomplete combustion, but there is no such constant relation in an average sample. Therefore, a great number of individual CO_2 determinations, each representing the conditions of the furnace during one short moment will, without the necessity of a CO analysis, show the amount of incomplete combustion, within the requirements of technical work.

This was recognized long ago in many places in Europe, and I once saw a boiler plant in which a boy was employed to make CO_2 analyses as fast as possible, taking his samples from one boiler after another. He had his place behind the battery of boilers and was supposed to record his results in a book provided for the purpose. However, the heat behind the boilers was rather conducive to sleep, and such is the frailty

of human nature that I believe the fellow took a quiet nap occasionally, and then to make up for lost time, manufactured out of a fertile brain a sufficient number of figures to fill in the blank spaces in his report. A machine has this advantage over a human being, that it requires no sleep and is not subject to the temptation to cheat. If it does cheat, it does so unintentionally and on account of mechanical deficiencies.

There has long been apparatus for the continuous recording of CO_2 in gases, but not until recently has there been a successful recording instrument of this kind. There are two kinds of these instruments on the market; one of which determines the quantity of CO_2 by observing the specific gravity of the gas, and another which depends on the chemical absorption of the CO_2 .

Of the specific gravity type the simplest is one in which the gas is led into a bulb suspended from one end of a balance beam. As the composition of the gas changes, and thus also the specific gravity, the bulb rises or descends and causes a pointer to indicate the percentage of CO_2 on a scale. This apparatus is good enough when new and in good order, but on account of its delicate construction it cannot easily be made recording.

Another instrument which determines the specific gravity of the gas, measures the difference in weight of a column of the gas and a column of air by means of a very sensitive draft gauge. This machine is made recording by means of a ray of light thrown on the end of a column of liquid in the draft gauge, which, when it moves, casts a longer or shorter shadow on a photographic film. This instrument is, without doubt, very admirable, but has the disadvantage of being very delicate and requiring a special foundation of brick or concrete, and furthermore, the record is not accessible until the film has been developed.

All of the instruments working on the principle of specific gravity have the drawback that they are accurate only for a gas mixture containing nothing but CO_2 and the oxygen and nitrogen of the air of combustion.

There remains, then the analyzing instruments working on the principle of chemical absorption of CO_2 , of which the one illustrated and described herewith is an example. This machine is not the first one of its type, but it is the latest, and therefore presumably the most perfect. It works on the same principle as most other gas analyzing apparatus. The gas is first measured carefully at atmospheric pressure, then brought in contact with the absorbing liquid, KOH , then measured again at the same pressure, the decrease in volume being the amount of CO_2 in the gas. By mechanical means this difference in volume is indicated on a chart graduated from 0% to 16% CO_2 . The confining liquid is mercury, the motive power is furnished by an exhauster capable of producing a vacuum of seven inches mercury.

The machine makes one analysis every five minutes.

During $2\frac{1}{2}$ minutes it draws in a new sample, and during the next $2\frac{1}{2}$ minutes it moves this sample through the absorption liquid, registers the amount of CO_2 on the chart, and at the same time draws a steady stream of gas through the pipes so as to provide a sample fresh from the furnace for the next analysis.

The movement of the gas in the different bulbs is regulated by a stop-cock which is turned by means of bulbs containing mercury. The latter is alternately drawn by vacuum into the one bulb, and runs back into the other by gravity when the vacuum is broken. This intermittent vacuum is brought about in the following manner: One of the bulbs is always in connection with the exhauster, but during the analyzing period this latter is not able to produce any vacuum in the apparatus, as there is a free connection with the gas supply. During the suction period this connection is cut off by the stop-cock and a vacuum is created in the machine. This vacuum is regulated to exactly six inches mercury by means of a regulator found at the left side of the machine. During the suction period this vacuum is used for lifting the mercury from one bulb into another in three places. In the power bulbs the weight of the mercury is shifted from the right-hand-lower to the left-hand-upper bulb, which thereafter is ready to drop as soon as the power arrangement is released by the clock. In the measuring bulb a fresh sample is drawn in, which is under the pressure of the stack until, at the very moment the bulb is full, the mercury uncovers the opening of a tube communicating with the atmosphere. A small volume of air, depending on the height of the vacuum of the stack, is thus introduced. If the vacuum of the stack is, for instance, 1 inch, and the amount of air let in is represented by V , and the atmosphere pressure of Denver is 326 inches of water, then,

$$V = \frac{325}{326} 100 = 99.7\%$$

We have, therefore, introduced 0.3% air. If the CO_2 content of the gas is 15%, the error caused by the admission of the air is $0.15 \times 0.3 = 0.045$, an error so small that it need not be taken into account. In this way the measuring bulb is made to contain a certain volume of gas, say 50cc., at atmospheric pressure.

The analyzing bulb is now full of mercury and the weighing bulb empty. When the stop-cock is reversed the vacuum is broken throughout the machine, and the mercury, running by gravity down into the measuring bulb, drives the gas sample through the absorption apparatus into the analyzing bulb. The gas, now decreased in volume owing to absorption of CO_2 , will drive an amount of mercury equal to its own volume out into the weighing bulb, which, when it has received a weight corresponding to 84% of the original volume, starts to descend steadily, maintaining the surfaces of the mercury in this bulb and in the analyzing bulb at the same level. The pen draws a line on the chart, and comes to a point of rest, when

the entire sample has passed from the measuring bulb into the analyzing bulb where it is again measured at atmospheric pressure.

The machine is supposed to work with gas saturated with moisture, as is generally the case with flue gas. If one is not sure that the gas is saturated with moisture, it is advisable to let it run through water before entering the machine.

For the proper working of a machine of this kind it is absolutely necessary that the gas be free from dust and soot. An efficient gas filter is, therefore, provided with each machine, to be placed on the boiler, and a second filter is placed on the machine itself. In this manner I believe that I have successfully coped with the most serious trouble inherent with mechanical gas analyzers, viz., getting soot or dust in the machine.

An objection to the first chemical CO₂ recorders was the impossibility of making more than five or six analyses an hour with complete absorption. By causing the liquid to be distributed over a large surface. I have been able to increase the number of analyses to 12 per hour with complete absorption, and could double this number if necessary. There is a constant circulation throughout the absorption apparatus, constantly exposing fresh liquid to the gas.

The chart is a continuous roll of paper, which obviates the necessity of renewing it every 12 or 24 hours. The pen always makes a clean line, without blotting or spreading the ink, so that the record of each analysis can be read, while the general record of the operation of the boiler plant over a period of several hours is apparent at a glance.

SOLDERING PLATINUM.

Soldering ordinary platinum vessels is done with platinum itself as the soldering material, or with pure gold, using the oxyhydrogen blow-pipe or its equivalent melting flame. Gold has the disadvantage that it melts at a lower temperature than the platinum, and under temperatures to which crucibles or other vessels may be subjected, it melts and leaves the crack open.

In *Central-Zeitung für Optik und Mechanik* it is recommended to close the crack with a mixture of platinum powder and turpentine oil, then to heat the joint to a white glow, and in this condition to hammer the parts together. Another method, applicable where the crack is on the edge, consists in hanging a narrow strip of platinum sheet over the crack, then placing the article in the fire, heating it white hot, and hammering if necessary.

According to *Metall-Arbeiter* a small hole may be closed by a rivet made of platinum wire, welded after hammering both heads closely. For larger holes a patch is made of platinum sheet, riveted on, and then welded.

THE GERMAN POTASH INDUSTRY.

BY A. M. THACKARA.

United States Consul General at Berlin.

Germany possesses the only known workable potash minerals, and the mining and manufacture of these has built up a most important industry.

A large and constant demand for potash salts has been developed in the United States for use as fertilizers in combination with the mineral phosphates of the Carolinas and Florida, and as a consequence great quantities of the German products are exported thereto [\$5,000,000 worth in the fiscal year 1908.—B. of M.]. The American consumption of German potash in various forms embraces more than one-half of the exported supply and nearly 18 per cent of the entire production; but while the great bulk of the potash salts consumed in the United States is from Germany, the latter is dependent upon the United States for more than one-half the mineral phosphates it uses. The total imports into Germany of these products in 1908 were 579,505 metric tons, of which 305,128 tons, or 5½ per cent, came from the deposits in the Southern States, while the balance came from Algeria, Tunis, Belgium, France and Australia.

DISAGREEMENTS FAVOR AMERICAN CONSUMERS.

As the prices which American farmers have to pay for their fertilizers are greatly dependent upon the cost of the German raw materials, a résumé of the present situation of the German potash industry should be of interest.

A disagreement over the quotas led to an open rupture in the German Potash Syndicate on June 30, 1904, so that at midnight the combine, which has been in existence for five years ending the following January 1st, expired as to the selling power of its members. The next day a new syndicate for five years ending January 12, 1910, was formed, but during the interval between the expiration of the old and the creation of the new syndicate the company which owned the Hohenfels mine made large five-year contracts with American buyers, and then joined the syndicate upon the condition that the sales would be accepted by that body. The new syndicate attempted to equalize prices and to charge the Americans a higher rate for the balance of their requirements. This was not satisfactory to the buyers, and some months later they contracted with the owner of the then recently established Sollstedt mine for their wants up to January 1, 1910, at prices lower than those of the syndicate. Besides the above sales, the Sollstedt mine made contracts with the syndicate's American customers up to 1917, deliveries to commence at the expiration of the then existing syndicate, January 1, 1910. These sales were made with a price guarantee clause that if lower sales were made to

other American buyers the prices were to be reduced in like proportion.

Efforts through committees to agree upon a plan by which the syndicate could be prolonged beyond the close of the present year have been progressing during the past twelve months. The negotiations reached an acute stage about ten days before July 1st last, when the participation quotas were taken up for discussion. At that time appearances were that no combine could possibly be formed, the interests of the older mines, financially strong, being opposed to those of the newer works. At midnight of June 30th, no agreement having been reached, and according to the provisions of the syndicate contract, the mines being free to sell at whatever price they chose, large sales were made by certain groups to American buyers. On July 24th a one-year so-called fighting syndicate was formed, with the Sollstedt and Aschersleben mines on the outside. This syndicate—should means be found

countries the remainder.

Calcined kieserit, 668 tons, 542 tons of which were for Germany and the balance for various countries.

Kieserit in blocks, 25,532 tons, of which 20,950 tons were consumed in Germany, 2,794 tons in United States, and 1,788 tons in all other countries.

Kainit and sylvinit, 2,388,381 tons, of which Germany consumed 1,613,556 tons, the United States 361,322 tons, and other countries 413,503 tons.

Carnalit and berg-kieserit, 74,385 tons, of which 71,403 tons were used in Germany, and the remainder exported.

In the following tabulated statement, compiled from official statistics, are shown the production of the potash industry of Germany during the past two years, the values of the products, and the average price per ton:

In a recent number of "Die Bank," one of the leading German economic magazines, there was an inter-

Description.	Metric tons.	1908		1907	
		Value.	Average value per ton.	Value.	Average value per ton.
Kainit	2,589,804	\$ 8,812,426	\$ 3.40	2,624,412	\$ 8,595,846 \$ 3.27
Other potash salts.....	3,500,635	8,664,630	2.30	3,124,956	7,265,426 2.33
Muriate of potash*.....	508,622	13,387,738	26.32	473,138	12,639,704 26.72
Sulphate of potassium.....	55,755	2,037,994	36.55	60,292	2,217,922 36.79
Sulphate of potassium-magnesium.....	33,149	633,068	20.00	33,368	631,652 18.92
*Including 117,390 tons of manure salts worth \$1,843,786, in 1908, and 83,763 tons of manure salts, worth \$1,193,332, in 1907.					

to take over or cancel the American sales—is to be extended until 1914.

According to the latest report of the potash syndicate, the following are the quantities of the various potash salts which were handled by its members in 1908:

Muriate of potash (chlorkalium) at 80 per cent., 288,524 metric tons, of which 105,281 tons were consumed in Germany, 104,048 tons were exported to the United States, and the remainder to various foreign countries.

Fertilizer at 80 per cent (muriate of potash), 21,268 tons, all of which was exported to Scandinavia and Denmark.

Sulphate of potash (schwefelsaures kali), at 90 per cent, 54,751 tons, of which Germany used 2,821 tons, the United States 26,000 tons, England 4,986 tons, France 6,110 tons, the remainder being sent to other foreign countries.

Calcinated sulphate of potassium-magnesium, double manure salts, at 48 per cent, 33,756 tons, 16,928 tons of which were sold to the United States, 15,124 tons to Holland, the remainder being consumed in Germany and other countries.

Crystal sulphate of potassium, at 40 per cent, 665 tons, all of which was used in Germany.

Manure salts (K_2O), at 20 per cent, 30 per cent, and 40 per cent, 284,989 tons, of which Germany consumed 171,016 tons, the United States 52,731 tons, Scandinavia and Denmark 24,005 tons, and other

esting article by Doctor Pinner on the overproduction and profits of the German potash industry. Speaking of the late syndicate, the doctor states:

One fact seems to be proved. The combine has not been able in the last few years to regulate the sales and the production, one of the essential requirements of a syndicate, and it will not be in a position for some length of time to establish normal conditions. This undeniable fact has been the theme of economists of different schools, who are trying to solve the question whether or not a syndicate organization is conducive to the development of the potash industry. Unmistakably, through overproduction and the founding of new works, elements of decomposition have shown themselves which threaten to undermine the strength and cohesion of the whole structure.

Owing to the difficulty of obtaining statistics, Doctor Pinner was unable to present a statement of the amount of capital invested and the profits of all plants running on full time for a number of years, but he gives comparisons of the results of certain mines between the year 1906, which was the last year of normal production, and 1908, in which, on account of overproduction, there was a considerable restriction of the output. The statement comprises only 21 mines, although there were 36 in the syndicate at the close of 1906, and one company, the Sollstedt, running on full time outside. The following works are omitted from the comparison: The four Fiscus (State)

plants; the Solway and Mansfield works, as they produce other chemicals besides potash, and do not separate their various products in their statement; Frischgluck, Heldburg and Sollstedt, as the yearly reports were not obtainable; Neu-Stassfurt and Ludwig II, as their statements do not show the amount of invested capital, as all the assessments have been written off; other works, as Desdemona, Grossherzog von Sachsen and Friedrich Franz, were not running on full time in 1906, as the mines were being developed. The Asse mine was obliged to almost cease operations on account of the flooding of its shaft, and the Runnenburg is not considered, because its capital account was debited too heavily with its investment in other mines.

The following statement, given by Doctor Pinner, shows the results of the operations of 21 potash mines in 1906:

The statement shows that the twenty-one works in question earned in 1906 an average profit of 15.9 per cent on the invested capital, and declared an average dividend of 13.5 per cent. It can be safely assumed that the works which were not considered in the state-

statements of most of the companies were not published at the time the article was written, only the actually paid dividends of the private mining concerns are stated, while the dividends of the stock companies are estimated. Comparisons between the amounts written off and the net profits could not be made.

Mines.	Paid-up capital.	Dividends paid.	Per cent of capital.
Westeregeln	\$ 1,909,200	\$ 209,916	10.5
Aschersleben	2,856,000	285,600	10.0
Wilhelmshall	440,300	.....	....
Glückauf	476,000	226,100	47.0
Hedwigsburg	190,400	.....	....
Burbach	723,520	190,400	25.9
Salzdetfurth	1,666,000	166,600	10.0
Hohenfels	1,063,860	128,520	12.0
Rossleben	1,439,900	130,900	9.0
Carlsfund	1,142,400	119,000	10.4
Hohenzollern	1,142,400	.....	....
Justus	1,190,000	.....	....
Kaiserroda	690,200	142,800	20.7

Mines.	Capital stock or paid-up assessments	Amortization and general reserve.	Net profits.	Dividends paid.	Per cent of capital.
Westeregeln	\$ 1,909,200	\$ 280,592	\$ 415,376	\$ 299,880	15.0
Aschersleben	2,856,000	189,320	307,805	285,600	10.0
Wilhelmshall	440,300	192,067	314,738	285,600	64.8
Glückauf	476,000	112,039	192,067	285,600	60.0
Hedwigsburg	190,400	82,739	223,322	199,920	105.0
Burbach	723,520	70,770	276,541	190,400	25.0
Salzdetfurth	1,666,000	142,819	277,358	233,240	14.0
Hohenfels	1,063,860	108,452	200,799	171,360	68.1
Rossleben	1,439,900	102,114	150,597	142,800	9.9
Carlsfund	1,142,400	86,215	181,921	154,700	13.5
Hohenzollern	1,142,400	58,991	119,000	119,000	10.4
Justus	1,190,000	83,468	16,639	47,600	4.0
Kaiserroda	690,200	84,951	147,560	142,800	20.7
Beienrode	1,011,500	48,777	142,800	142,800	14.1
Jessenitz	1,190,000	110,466	118,626	95,200	8.0
Wintershall	1,094,800	116,411	147,941	147,941	13.5
Sigmundshall	476,000	28,485	23,555	27,718	5.0
Einigkeit	1,568,865	83,439	118,413	.....	....
Alexandershall	761,280	132,248	216,821	142,800	18.7
Thiedershall	952,000	79,462	84,110	66,640	7.0
Johanneshall	1,428,000	73,331	71,581	.....	....
Total	\$23,502,625	\$2,267,156	\$3,747,570	\$3,175,599	....

ment also reached this average, as among them were a number of the most profitable mines and but few of the minor companies. Since the works in 1906 while running to their normal but not to their full capacity, distributed an average dividend of 13.5 per cent, it may be stated that the potash, up to 1906, was one of the most profitable of German industries.

In the article by Doctor Pinner the following table was given, which shows the change in the profits made in 1908 by the same 21 works. As the yearly

Beienrode	1,011,500	119,000	11.7
Jessenitz	1,190,000	71,400	6.0
Wintershall	1,094,800	190,400	17.3
Sigmundshall	833,000	.....	....
Einigkeit	1,568,865	71,400	4.4
Alexandershall	761,280	142,800	18.7
Thiedershall	952,000	28,560	3.0
Johanneshall	1,428,000	47,600	3.3
Total	\$23,850,625	\$2,270,996	9.5

It will be seen by the above statement that the average profits of the 21 works under consideration were reduced, inside of two years, from 13.5 per cent to 9.5 per cent. The passing of the dividend by the Wilhelmshall mine was owing to extraordinary expenditures for enlarging the plant and for constructing a second shaft. The following is a statement showing the highest quotations of the stock in marks (1 mark = 23.8 cents) of the same companies during 1906 and the quotations on January 30, 1908:

Mines.	Par value.	Quotations	
		Highest in 1906.	Jan. 30, 1908.
	Marks.	Marks.	Marks.
Westerregeln	100	263	168
Aschersleben	100	188	131
Wilhelmshall	1,850	16,100	9,200
Glückauf	2,000	20,200	15,800
Hedwigsburg	800	11,200	.....
Burbach	3,040	15,750	11,500
Salzdetfurth	100	280	164
Hohenfels	4,470	11,050	5,750
Rosslieben	6,050	10,400	8,000
Carlsfund	4,800	12,500	5,700
Hohenzollern	4,800	9,150	3,200
Justus	100	182	70
Kaiseroda	2,900	10,450	6,600
Beienrode	4,250	9,475	4,600
Jessenitz	100	142	99
Wintershall	4,600	15,500	11,700
Sigmundshall	100	375	125
Einigkeit	6,591	8,350	4,700
Alexandershall	3,198	10,500	6,750
Thiedershall	100	148	87
Johanneshall	6,000	7,650	3,300

COST OF PRODUCTION AND PROFITS.

In his discussion of the position of the potash industry, as developed under the régime of the late syndicate, Doctor Pinner gives some interesting information as to the costs of production of the various grades, based upon expert opinion, it being impracticable, for various reasons, to give the official figures. The following statement shows the costs of production and the foreign and domestic prices of the several grades per 220.46 pounds, according to Doctor Pinner's figures.

Grade.	Per cent.	Cost of production per 220.46 pounds.		Price per 220.46 pounds.		
				Foreign.	Domestic.	
Kainit	12.4	\$0.1547	to \$0.1904	\$0.405	to \$0.452	\$0.338
Muriate of potash.....	80.0	1.19	to 1.785	3.38		3.38
Sulphate of potash.....	90.0	1.666	to 2.618	3.92		3.92
Manure salts	40.0	0.833	to 1.19	1.52		1.52

Excepting the 40 per cent manure salts, the production costs of which are higher, in consequence of the small output of the various works, the costs of production of the above products vary between 40 and 60 per cent of the receipts from sales. These figures are based on the normal running time of the works in 1906. In the

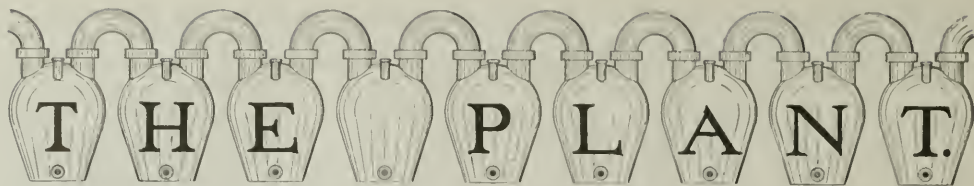
last two years the costs of production have somewhat increased. They may have even in some cases passed the maximum of 60 per cent. Still the costs of production are low when compared to those of other mining industries. In coal mining, for example, the production costs are considerably higher, amounting to from 70 to 80 per cent of the total receipts, and often even greater. The report of the Harpener Mining Co. for 1907-8, shows a cost per ton of coal of \$2.05, with an average sale price of \$2.69; the König Ludwig Mining Co. sold coal in 1905 at \$2.44 per metric ton, against a production cost of \$2.26, and in 1906 at \$2.43, against \$2.25. Yet the original costs of plants and the capital invested in coal mines are not smaller than in the potash industry. On the contrary, they are generally higher, on account of the law requiring the 2-shaft system having been in operation for years. These facts explain how the selling policy of the potash syndicate and the comparatively low costs of production have stimulated the establishment of new plants.

THE POTASH SYNDICATE AND AMERICAN INTERESTS.

The following is a translation of an article which appeared in the Berlin Börsen Courier, one of the leading local financial journals, August 3, 1909, expressing its opinion on the present situation of the German potash industry:

It is reported that H. Schmidtman is to leave tomorrow for the United States. Mr. Schmidtman has accepted the task of endeavoring to secure an agreement for the annulment or other disposition of the contracts which were made outside of the syndicate by the Aschersleben-Sollstedt group, with the Northern trust, with the International trust, and with the former syndicate's agents. It is hoped that this agreement may be such that the executive committee, to which additional power has been granted, will be able to decide, on September 25th next, by a unanimous vote, whether or not the disposition to be made of the contracts in question is in the interest of the syndicate. If a satisfactory arrangement is agreed upon and a suitable agreement is entered into with the Southern trust and with the selling combination of Westergeln-Salzdettfurth, it is most probable that the present combine will be transformed into a 5-year syndicate.

If such an agreement is not reached before September 30th next, it is doubtful that the Einigkeit-Westeregeln-Salzdettfurth will join the syndicate. Furthermore, all the other companies have the right to leave the syndicate in case Einigkeit and Westeregeln take advantage of their privilege to withdraw.



VACUUM EVAPORATION.¹

By P. B. SADTLER.

Chemical Engineer, Swenson Evaporator Co., Chicago.

It is a notable fact that, in this country at least, the knowledge of construction and operation of vacuum evaporating apparatus is very limited. There are a few industries, among which are the glucose, cane and beet-sugar industries, where the engineers are in general pretty thoroughly familiar with this subject. Outside of these industries ignorance of the basic principles of evaporation actually frequently prevents engineers and superintendents from obtaining the best results. Those operating vacuum apparatus in their plants are prone to drop the subject completely as soon as their apparatus has been "broken in," only to take up the subject again when something goes wrong or when increased capacity must be installed to meet the demands of a growing business. Besides this class there is a long, though gradually diminishing, list of factory owners and others who either have entirely neglected to consider this important subject, or who, on doing so, have been frightened by some obstacle that seemed unsurmountable.

In this article will be discussed only the form of evaporator in which saturated steam is the heating medium, as no evaporation can at present be done by direct fire so well as in the approved types of boiler, where the steam for the evaporator is made. The reasons why direct fire evaporation does not as a rule pay will be discussed on a later page.

A close evaporator heated by steam coils has the following advantages:

1. Less steam is used because the apparatus is smaller and there is no exposed surface of boiling liquid, hence the amount of radiation and consequent loss of heat is reduced.

2. When evaporating under vacuum the temperature of the system is so lowered as to be nearly down to that of the atmosphere, with the result that the radiation loss is decreased. In other words, if a liquid is boiled in an open pan under atmospheric conditions the boiling point may be 220° F., or 150° above average atmospheric temperature. In a single-effect vacuum evaporator the average temperature may be 138° or 68° above atmospheric temperature. The radiation from the open pan would compare with that of the vacuum pan as 150° to 68° roughly.

3. The above considerations, however, are of little

importance compared with the fact that a vacuum evaporator, either single or multiple-effect, may be run by using, as a heating substance, the *exhaust steam* from engines, pumps, etc., thus enabling certain establishments to run an evaporator at practically no cost for steam.

4. There are many liquids which should be kept below the temperature 280° to 300° of high pressure steam coils, or even below atmospheric boiling point 212° F. Among these are such as sugar, glucose, sugar of milk, milk, glue, glycerine, etc.

5. Greater temperature differences may be attained in single effects, hence greater capacity for a given size apparatus.

6. When multiple-effect evaporators are used, the steam economy is increased to such an extent as to make the steam consumption run as low as 1/5, in some cases, of the actual amount of water evaporated from the liquid. There are some industrial concerns at present which could not operate and pay dividends without multiple-effect evaporators in constant use.

MULTIPLE-EFFECT PRINCIPLE.

The most primitive illustration of a multiple-effect evaporator is seen in an organic laboratory every day. Frequently a so-called volatile substance is put into a flask connected to a condenser and heated by a steam bath in which water is boiled. The vessel containing the boiling water is the first effect of a double-deck evaporator and the flask containing the low-boiling substance is the second effect. In the case of large scale work instead of boiling off a naturally volatile substance in the second effect, we boil off water whose vapor above it is kept at reduced pressure, thus making the water a relatively low-boiling substance. Thus in practice we have a succession of pans or effects, the coils of each one of which gets its heating vapor from the liquid of the preceding pan. The first pan of the series takes its heating vapor from the original source, the boiler or exhaust pipe of an engine; the last effect gives up its vapor to a condenser in which the highest vacuum is maintained. Any important point to be borne in mind is, that every effect is the condenser that brings about the pressure reduction necessary for the operation of the preceding pan.

The most popular and universally serviceable evaporator is the triple-effect, although they are in daily operation on a large scale up to sextuple-effect. In fact, multiple-effect water stills have been operated in twelve successive effects. A definite determination of the number of effects to use to obtain the best economy when working on any given solution, is diffi-

¹From the *Journal of Industrial and Engineering Chemistry*.

cult to make. The best tests, of course, are those made on the large evaporators and as some expense and annoyance to the owner may result, the proper scientifically conducted tests are not carried out. One can, therefore, only go by the judgment of the designers and experts in this field in determining the best layout for economical multiple-effect evaporation.

STEAM CONSUMPTION.

Before discussing at length the factors governing the steam consumption in an evaporator, it is well to state several fundamental facts to be proven later.

1. *The number of effects used in an evaporative system does not necessarily bear any relation to the evaporative capacity of the system.*

2. *A given amount of water at the boiling point to be evaporated requires a corresponding amount of steam to evaporate it irrespective of the form or size of the vessel in which the evaporation is accomplished. Speaking broadly, a pound of water evaporated requires that a pound of steam be condensed in a single effect.*

3. *The capacity of a heating surface is dependent on the temperature of the steam and not the pressure resulting therefrom.*

4. *An evaporator should not be considered as a heat engine, as it does no external work.*

To get the best idea of the heat transactions in the evaporator, we should consider one effect at a time. Also, for simplicity, assume that the effects are of the same construction and bear in mind that each one is the condenser to produce the vacuum in the preceding effect. For every pound of dry steam entering the coils of the first effect, there is one pound of vapor produced by the evaporation of the solution which we assume enters at the boiling temperature. As only a fraction of the total amount of water is to be evaporated in the first effect, the solution passes partly concentrated into the next effect. But as a lower pressure, and consequently lower temperature, is being maintained in the second effect, the solution passes in a superheated condition to the next effect, where a certain amount of evaporation takes place, due to the lowering of the pressure. Therefore in the second effect we have to expect the evaporation of another pound, plus increment due to the changing part of the heat of the liquid into heat of vaporization. Likewise in the third effect there is produced evaporation to the extent of a pound, plus two increments. In other words, the latent heat of a pound of steam is transferred through the heating surfaces of one effect after another, the amount of steam being, however, gradually increased by the spontaneous evaporation of the solution passing from one effect to another successively in a superheated condition. Finally this heat passes into the cooling water of the condenser and is lost. If we were to assume that there was no radiation of heat from the system and that pure water were being boiled, the above conditions would be always true and, in a sextuple effect, a single pound of initial heating

steam would accomplish the evaporation of between six and seven pounds of water.

In actual fact, however, we have to contend with the consumption of heat in two other directions:

1. In concentrating any solution we have to accomplish the partial separation of a liquid from a solid. There is, of course, a certain solution pressure against which we must work, and the actual amount of energy expended in this way is measured by the free energy of the chemical reaction of solution. This is not considerable when we concentrate to ordinary density. Hence it may be said that *the total reversible energy expended in evaporation is equal to the free energy of reaction.*

2. There is a radiation loss from each effect depending on the number of effects, their temperature with respect to atmospheric temperature, the amount and quality of the insulating covering used and other conditions such as degree of exposure of the apparatus to the weather.

These losses are cumulative from one effect to another so that where a solution has boiling points appreciably over that of water, it is not economical to attempt the operation of more than a limited number of effects.

DIAGRAMS.

To illustrate several cases of heat transactions obtaining in an evaporator:

Figure 1 shows a multiple-effect heat diagram similar to that of Hausbrand for pure water in a quadruple-effect evaporator, where it is assumed that the differences in temperature from one effect to another is infinitesimal and where water enters at boiling temperature and the vessels do not radiate heat.

Figure 2 shows a heat diagram for a triple-effect where the assumptions are made that the solutions enters at atmospheric temperature, the solution has an appreciable excess in boiling temperature over that of water, and there is an appreciable temperature difference from one effect to another. The white areas represent the steam condensing and causing evaporation; the shaded areas represent the heat and energy losses as expressed in steam. The areas shown are not definitely measurable or calculable, but merely in the diagram show the tendencies existing in an evaporation system.

The heat transferences taking place in a multiple effect are altered in character to a great extent by the method of feeding the solution to be concentrated and the method of preheating if such is necessary. There are four ways of feeding the solution to the evaporator.

1. The dilute solution is fed entirely into the first effect and passes successively from one effect to another at higher and higher concentrations.

2. The dilute solution is fed in equal amounts separately into each effect, and boiled in each at the same concentration.

3. The dilute solution is fed entirely into the

last effect and passes back to the first effect, a method known as running backward.

4. The dilute solution is pumped into the whole evaporator before starting and boiled in batches.

While inquiring into the relation, merits and advantages of these methods, let us consider at the same time the methods of bringing the dilute liquor to the boiling point and the bearing of these methods upon the heat transactions.

While in many cases a recently completed chemical reaction or industrial process leaves the dilute solution at a temperature approaching the boiling point, such as we find to be the case in certain mercerizing work, in electrolytic soda work or packing house rendering, there are other cases such as brine evaporation or sugar evaporation where the most efficient process necessarily includes the preheating of dilute solutions. In general, it may be said that running a comparatively cool solution into an evaporating apparatus decreases its efficiency and interferes with proper operation.

The usual method of preheating in running a multiple-effect concentrating evaporator as mentioned, in case 1, above, is to employ a steam heater to preheat the solution entering the first effect by the use of live or exhaust steam. Frequently it is assumed that it is quite sufficient to turn on a little extra steam and run the solution cold into the evaporator. When this is done a portion of the heating surface of the effect, into which the cold solution is run, plays the part of a preheating apparatus. An evaporator is an expensive article to use as a preheater.

Where evaporating at equal densities, as in the second case above, there may be attached to each effect a countercurrent heater in which the water of condensation, flowing from an effect, partly preheats the liquor being pumped into the effect. It can readily be perceived that the amount of heat that can be transferred to the solution from the water of condensation is insufficient to bring the former up to the required boiling point. This method is only applicable to precipitation work, as in multiple-effect salt evaporators.

When "running backwards" preheating is not often the practice as the boiling point of the last pan, the one which the solution enters, is not very high and the step up in temperature from one pan to another is not very great. This method has the advantage, but other things being equal, that in the pan with the densest solution, there is the highest temperature, which tends towards better circulation and consequently higher efficiency. In using this method it is necessary to pump the liquid out of one effect into the next. The fact that steam is used to do pumping need not have much bearing on the question, as it must be borne in mind that the exhaust steam from pumps is available for evaporation purposes.

The total consumption of heat in a multiple-effect is composed of the energy consumed in actual separation of the liquid and the solid in solution; the radiation

of heat from the walls of the vessel; the heat passing away in the circulating water of the condenser; and the heat passing away in the condensation water. In a test on an evaporator these can all be determined by actual measurement except the energy of evaporation and the radiation loss. There is always considerable doubt as to just what the latter amounts to in various types of evaporator and with various coverings. It is possible to measure it by special test, though this is rarely done. The energy of evaporation may be calculated for certain solutions and simply depends on a formula which may be derived from the gas laws.

It is shown by Nernst in the last edition of his "Theoretical Chemistry" that the energy expended in evaporation is

$$K \times R \times T \times (C - C'),$$

where R = the gas constant, T = the absolute temperature, C' = initial concentration, and C = the final concentration both expressed in mols. of salt per mol. of water. For certain inorganic salts these constants have been determined, being derivable from the vapor pressure curves.

EFFICIENCY AND EVAPORATIVE CAPACITY.

A heat engine is an apparatus that transforms a portion of the heat received into dynamic energy. An evaporator is not a heat engine, therefore, but if the assumption be correct that solution is a chemical combination of solvent and solute, an evaporator transforms heat into chemical energy. When following this analogy between a heat engine and an evaporating system, we find that as a matter of fact the efficiency

$$\frac{Q - Q'}{Q}$$

or the quantity $\frac{Q - Q'}{Q}$, where Q is the heat entering

and $Q - Q'$ is the heat transformed in chemical energy, is very low. The heat disposed of through other channels is very great. For instance, the latent heat of the entering steam eventually finds its way in large part into the circulating water of the condenser. Therefore, it will readily be seen that if, as we have shown above, this energy demanded for evaporation is entirely dependent upon absolute temperature and degree of concentration, *no high type of evaporator has more efficiency than another, but the efficiency is entirely dependent upon the solution and its attendant physical conditions.*

This matter of efficiency is noted here as there is an erroneous conception among some evaporator engineers as to the meaning of the word efficiency. It has been the practice among some to speak of the relative amount of evaporation per unit area of heating surface as the efficiency of an evaporator. The difficulty with using the term efficiency where the term capacity or duty would be more applicable, is that it leads those unacquainted with the principles to the idea that greater or less consumption of heat obtains in different types of evaporators. In different types of evaporators the evaporative capacity does vary con-

siderably, but it is not the purpose of this article to discuss this side of the question, as the relative merits and demerits of different makes of machinery demand a separate article.

Before discussing the subject, of capacity and the calculation of heating surface, it is well to approach the subject from the point of view of transmission of heat through the heating surface.

HEAT TRANSMISSION.

Heat transmission is measured by four fundamental factors, namely, temperature, weight, space, and time. To be more specific, the common combination of units, in which we express heat transmission, is British thermal units, per square foot, per hour. Therefore, the coefficient of the heat transmission of a medium would be the figure which gives the number of British thermal units passing per hour from a warmer to a colder substance through one square foot of the medium for which we desire the coefficient.

It will readily be seen the ability of the medium to transmit heat in a greater or less degree is governed by the following factors, namely, nature of the material, thickness of the medium, difference in temperature of the warmer and the colder substance. Hence, we have

$$h = k \frac{(t - t')}{d} m,$$

where h is heat transmitted, m is the time during which transmission takes place, d the thickness of the transmitting medium, $t - t'$ difference in temperature, and k a constant dependent on the nature of the material.

From the above we see that

$$k = \frac{d \times h}{(t - t') m},$$

whence we are able to determine a constant k for any material by determining d , h ($t - t'$), and m for one square foot of heating surface. For practical purposes, where for a given material the limits of the factor d are quite narrow, this is omitted and the constant becomes

$$k = \frac{h}{(t - t') m}.$$

In the case of the transference of heat from one substance to another, for evaporative purposes, we have several possibilities: that of heat passing from a liquid, from steam or from other gases; also heat passing to a body of liquid or to a film of liquid.

In evaporation work the case of heat passing from a liquid is not of very wide importance. Other things being equal k would be high in this case, but the difficulties involved in this method of heating necessarily outweigh those of steam heating. A high-boiling liquid may be heated and made to pass through heating tubes, giving a high transference constant, but the velocity necessary for its passage through the tubes is great enough to make the idea unworthy of consideration.

In the case of saturated steam there is not the same

necessity for an appreciable velocity directly in relation with the walls of the heating tubes, though this is very desirable. Unlike the case of direct heating, the effect is obtained by the latent heat of vaporization. Although the heating of the liquid is not due to difference in temperature between the steam and the liquid being heated, there must be a quite appreciable difference in temperature to make effective use of the latent heat. The larger the difference in temperature the greater is the heat transmission of the metal walls.

As water dissolves air is to a small extent the steam from the boiler always contains air in greater or less amount. This air tends to lessen the heat transmission so that it will be found in practice that better boiling takes place in the heating coil, where the velocity is considerable.

It can readily be seen, therefore, that the presence of air in the heating steam is detrimental. Just as air reduces the heat transmission so also does the water produced by condensation of the steam. The heat conductivity of water is far below that of a metal, so that a steam coil containing a layer of water is not fully effective.

The usual case of heating by other gases than steam is direct firing of boilers or evaporators, or the utilization of waste heat from furnaces, incinerators, etc. Here the transmission of heat is due to the difference in temperature and the velocity of the gas. It will readily be seen that if a body of cooled inert, non-condensable gas stays in contact with the wall of the heating surface the efficiency of the locality where that takes place is greatly reduced. On the other hand, in the case of steam the pressure back of the heating steam is cause for constant supply of the steam, which gives up its latent heat to the wall of the heating surface. A non-condensable gas, to be equivalent in effect to a condensable gas, like steam, must be led against the heat-transferring wall with considerable velocity to cause the rapid removal of cooled gas and prevent lodging of cooled gas in any small corners or devious places.

Very little can be determined as to the theoretical side of the transmission of heat to different solutions and solids. In general, it may be said that the completeness of the circulation of the liquid, the consequent rapidity of the disposal of the steam formed at the contact between the liquid and the heating surface, and the degree of mobility of the liquor are the chief factors for consideration here. More can be said later of interest and of value from a practical standpoint.

The heat transmission may be said to be greater when the liquid is in contact with the heating surface in as thin layers as possible. This is accomplished by allowing the liquor to spray or trickle over the heating surface or by bringing the liquor in contact with the surface in the form of a foam. When a film is in contact with the heating surface the evaporation may be said to be local; hence there is a local cooling tendency and consequent greater temperature difference

between the liquor heated and the heating gas. This it will be seen will increase the heat transmission.

There has been an erroneous notion prevalent among some engineers that the evaporative capacity of a heating surface of any given form and area is inversely proportional to the thickness of the wall of the heating tube and proportional to the heat conductivity of the particular metal used. The idea is quite wide of the mark, as decided by results. If two otherwise equal evaporators be installed in which one has heating tubes of 20-gauge and the other 15-gauge, such a theory would require that the latter would have half the evaporative capacity of the former, 15-gauge being twice as thick as 20-gauge. As a matter of fact the difference due to this variation and thickness is negligible. However, the difference between the evaporative capacities of two heating surfaces of different metals is measurable if two metals of widely different conductivities be chosen, but even then the difference is not as great as might be supposed.

Kent gives, among others, the following conductivities:

Silver	1000
Copper (rolled)	845
Iron (wrought)	436
Steel	397

In spite of these figures the evaporative factor of copper tubes is only 10 per cent to 15 per cent greater than that of steel tubes.

To explain these facts we must consider that the resistances of the metallic wall to the passage of heat are threefold, namely, (1) resistance of entry of heat into the metallic wall, (2) resistance to passage through the wall, (3) resistance to the exit from the metal to the boiling solution. Let these resistances produce conductivities a , b , and d , respectively. Let C represent the evaporative factor of the metal by experiment.

$\frac{1}{C} = \text{total resistance} = K \left[\frac{1}{a} + \frac{1}{b} + \frac{1}{d} \right]$ or the sum of the three resistances.

$C = \frac{1}{K \left[\frac{1}{a} + \frac{1}{b} + \frac{1}{d} \right]}$ where K is an arbitrary constant.

Conductivity is effected by the ease with which the steam for heating is carried off and also the velocity of the steam; conductivity b is constant for a given metal; conductivity d is dependent upon the solution being handled, its boiling point, mobility, scaling properties, etc.

Barium carbonite is mined in the Thuringian mountains, Germany, and is known as witherite. The barium carbonate commonly shipped to the United States is an artificial product, obtained by the treatment of BaS with CO_2 gas, and boiling. The material so made is used for the manufacture of bricks of even color and of terra cotta; it is also employed in the glass and earthenware industries.

NITRIC ACID.

By SCHUYLER FRAZIER.

Chemical Engineer, Bistol, Tenn.

Formula.—Nitric Acid— $\text{HNO}_3 = 63.02$ Mol. Wt.

General Description.—When pure, this acid is colorless, but becomes yellowish if of high strength, being slowly decomposed by the action of light. Ordinarily the acid is of straw color owing to presence of lower oxides of nitrogen.

Properties.—Nitric acid is a liquid which acts as a strong caustic on animal matter staining the skin an indelible yellow color. On vegetable fibre, it re-acts to abstract hydrogen or water and combine with the remaining elements. When diluted, nitric acid con-

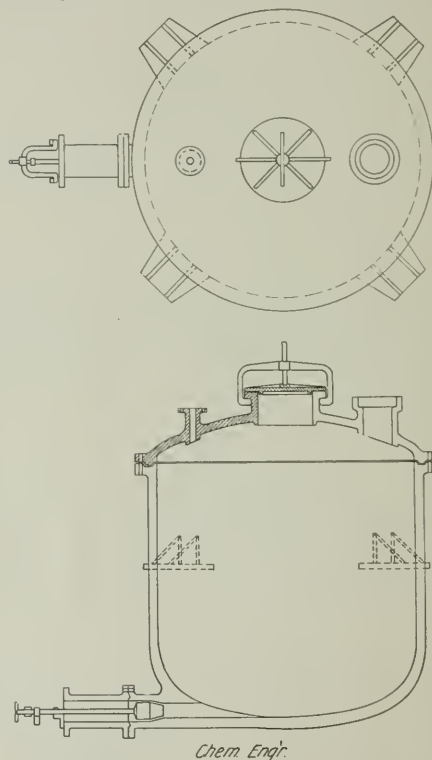


Fig 1—Retort for Nitric Acid Manufacture.

verts most animal and vegetable substances into oxalic, malic and carbonic acids. In general the action of nitric acid is to impart oxygen to other bodies. Strong nitric acid requires care in handling as contact with combustible substances is likely to cause fire. Nitric acid combines with the salifiable bases forming nitrates.

Principal Uses and Trade Requirements.—Nitric acid is known to the trade in the following several qualities or grades, viz.: (1) Absolutely C. P.; for laboratory use and containing no impurities; (2) C. P.

analyzed—containing only traces of impurities denoted on label and suitable for most analytical uses; (3) nitric acid U. S. P. being practically pure acid according to specification given in U. S. Pharmacopœia; (4) practically pure nitric acid free from chlorine and lower nitrogen oxides—nearly colorless—this grade is demanded by manufacturers of nitrate of ammonia, nitrous oxide gas, silver nitrate, collodion, etc.; also for nitro-glycerine, gun cotton, etc.; (5) ordinary yellow and reddish crude nitric acid, containing traces of iron, sulphuric acid, chlorine and more or less lower nitrogen oxides—known as commercial acid—used to clean brass articles and for other common manufacturing purposes; for manufacture of various chemical products; (6) a mixture of nitric and hydrochloric acids in various proportions sold as aqua regia, pickle fluid, nitro-hydrochloric acid—this is used in various industries where an acid is required to dissolve metals or clean them very actively.

Strengths of nitric acid are ordinarily these for laboratory use $42\frac{7}{10}^{\circ}\text{B}^{\circ} = 1.420$ sp. gr. For pharmacy the same. For ordinary commerce $36^{\circ}\text{B}^{\circ} = 1.332$ sp. gr.; $38^{\circ}\text{B}^{\circ} = 1.360$ sp. gr. $= 40^{\circ}\text{B}^{\circ} = 1.383$ sp. gr.; $42^{\circ}\text{B}^{\circ} = 1.410$ sp. gr. For gun cotton $43\frac{1}{2}^{\circ}\text{B}^{\circ} = 1.430$ sp. gr.—more or less, and for nitro-glycerine, smokeless powder, etc., 94% HNO_3 —more or less—according to specifications of manufacture of these substances.

Crude Materials and Methods of Manufacture.—Nitrate of soda— NaNO_3 = Mol. Wt. 85.01 is the substance from which nitric acid is most commonly derived. Nitrate of soda is principally imported from Chile and the grade generally purchased for the purpose contains 96% NaNO_3 . The impurities consist of organic matter, water, common salt, etc., etc.

The nitrate of soda is decomposed by means of strong sulphuric acid in cast iron retorts, the nitric acid distills off as a gas and condenses to a liquid upon cooling in stoneware jars or similar apparatus. In the retort remains bisulphate of soda which later is generally utilized in the manufacture of muriatic acid and to some extent in extraction of antimony from its ore, also for other purposes.

Details of Manufacture.—A practical method of manufacturing nitric acid is as follows:

The formula $2(\text{NaNO}_3) + \text{H}_2\text{SO}_4 = \text{Na}_2\text{SO}_4 + (\text{HNO}_3)_2$ is not usually employed because the high temperature required to complete the reaction causes loss of HNO_3 by decomposition to lower oxides of nitrogen; also the Na_2SO_4 becomes a solid cake in the retort causing difficult removal. Consequently the following formula is mostly used $\text{NaNO}_3 + \text{H}_2\text{SO}_4 = \text{NaHSO}_4 + \text{HNO}_3$.

For ordinary strengths of nitric acid the sulphuric acid used is $66^{\circ}\text{B}^{\circ} = 93\frac{1}{2}\%$ H_2SO_4 .

For production of 94% HNO_3 the sulphuric acid used is 97% to 98% strength and the NaNO_3 fairly dry. A retort receives 2000 lbs. nitrate soda and 2200 lbs. sulphuric acid 98% (2400 lbs. if 93½%) at 5

p. m., distills slowly to 100 a. m. next day and cools from 10 a. m. to 5 p. m. This cooling of the retort to a rather moderate temperature is desirable because if the retort is too hot when charged, the distillation begins too violently causing loss of HNO_3 vapors. The nitrate soda is dumped into the retort, through a charging hole which is closed by a cover clamped on, then the measured quantity of sulphuric acid is run into the retort through a funnel tube. Fire is then started under the retort and carefully regulated so as to produce a uniform distillation of nitric acid. Care is required in the firing, otherwise the generation of

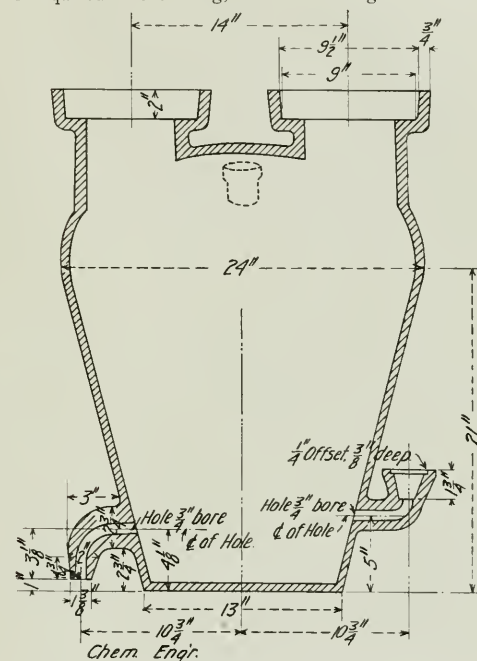


Fig. 2—Special Receiver for Condensing Nitric Acid.

nitric acid vapor may at times exceed the capacity of the condensers and a loss of acid result.

Form of Apparatus.—There have been many types of retorts used, some of which have been abandoned and replaced by those of more convenient form.

A very satisfactory retort is of cast iron about 6 ft. diameter and 6 ft. high, pot shape, having a crowned cover bolted on. In the cover is provided a manhole 16 inches diameter for charging the sodium nitrate, a hole suited to connect a 6-inch stoneware pipe for delivery of nitric acid vapor to condenser, also a hole 2 inches diameter to receive a funnel tube for charging the sulphuric acid. The bottom of the retort is provided with a 4-inch diameter side outlet for tapping out the molten sodium bisulphate remaining after distillation. This tapping hole is closed by a suitable iron plug closing against a seat provided in the tube. A ball of clay is rammed in the opening and the plug forced in against it. The sodium bisulphate

is tapped out by removing the iron plug and then the clay ball is perforated by a long iron rod. A cast iron bodied tramcar receives the molten bisulphate and transports same to point of disposal.

The retort is completely enclosed in a brick fireplace of exterior dimensions about 9'x9'x10' high. A number of retorts are usually arranged in a row each with a separate fire. A tramway laid over the retorts allows the nitrate soda charge to be dropped directly into the retorts from a hoppers tramcar. For each retort is provided a lead lined box to measure and hold the sulphuric acid required.

The Condenser.—For each retort is provided an independent condenser consisting of a row of ten or twelve stoneware jars of 50 gal. capacity of style known as "receivers." Usually the first six receivers, at least, are set on steps and connected at bottoms by stoneware tubes so that the bulk of the acid condensed flows toward one point and is conveyed by glass tubes into cooling jars located on platform 2½ ft. above the floor. From the cooling jars the acid is siphoned into

usually amounts to less than 10% of the entire product and on account of inferior quality and low strength it is generally utilized in other manufacturing processes, viz., in making sulphuric acid.

Referring now to the nitric acid condenser proper it is to be remarked, that if the nitric acid is condensed, as in former times, in receivers which have no provision for flowing the acid always from the cooler

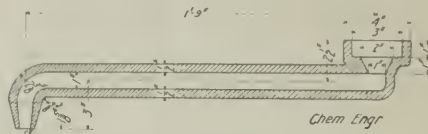


Fig. 4—Details of Chemical Stoneware Pipe for Connecting Condensing Jars.

into the warmer receivers, then the acid has to be siphoned separately from every receiver and being cold it has absorbed and contains a large percentage of lower oxides.

The present practice is to employ any convenient form of condenser which will cause the condensed acid to travel in a direction opposite to that of the hot gasses coming from the retort. By this means the acid is automatically heated sufficiently so that the lower oxides are driven out. This action is further facilitated by causing all condensed acid to flow into the top of a receiver placed close to the retort, the acid falling into a dish within the receiver which is thor-

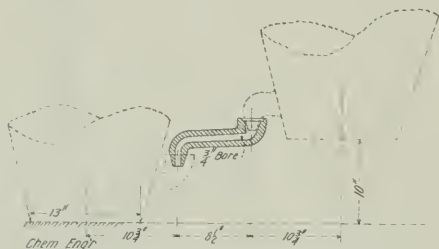


Fig. 3—Method of Connecting Receivers.

carbonyls. On tops of all receivers are vertical columns of 6-inch stoneware pipes—to afford natural cooling of the nitric acid gas—these pipes are connected above by suitable half circle bends. Practically all the nitric acid condenses in the above described receivers and pipes but the lower oxides of nitrogen pass out in gaseous state and require further treatment for recovery.

To recover the lower nitrogen oxides all the exits of the several condensers are connected into a stoneware pipe leading to the recovery towers. The recovery towers are about 20 ft. high and made of 30-inch sewer pipe supported on stoneware dishes. The nitrous gases enter the top of the first tower through a 6-inch stoneware pipe arranged with a steam injector which draws in a regulated volume of air. The air and steam serve to oxidize the nitrous oxides to nitric acid in the first tower which is empty except as to loose packing of stoneware cylinders 5 ft. high. The warm nitric gas leaving the bottom of this tower passes through some cooling pipes or receivers and enters bottom of second tower. The second tower is completely packed with small stoneware cylinders and fed with a small water spray at top which serves to condense the last traces of nitric acid.

The nitric acid recovered from the nitrous gases

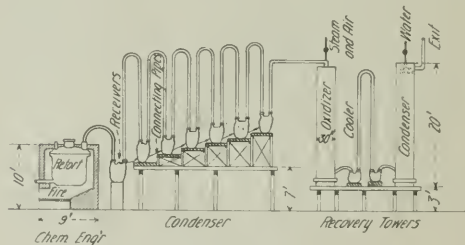


Fig. 5—Nitric Acid Plant.

oughly heated by the gas from the retort and the acid in the dish being agitated by compressed air delivered through a ¼-inch glass tube.

The resulting nitric acid is nearly white and contains under 0.3 10% of lower oxides.

When producing 94% HNO_3 it is customary to flow the acid through a 1½-inch lead pipe 10 ft. long laid horizontally in water bath. This cools the acid very effectively and allows it to flow into lead lined collecting tanks and monteius delivering to desired point. Nitric acid of 94% strength or thereabouts is largely used in preparation of "Mixed Acid" for use of manufacturers of nitroglycerine, etc. Usually the nitric acid is obtained pure enough for this purpose. For some purposes the nitric acid must be entirely free of nitrogen oxides and chlorine and therefore must be heated in stoneware jars in water bath and well blown with compressed air.



THE DETERMINATION OF TITANIUM IN ARGILLACEOUS LIMESTONES (CEMENT ROCK.)

By H. M. ULLMANN and J. W. BOYER.

Lehigh University, South Bethlehem, Pa.

The method for the immediate determination of titanium was devised as primarily applicable to the argillaceous limestones quarried as cement rock in the Leigh Valley district, and has been found adapted to the analysis of other limestones and to some specimens of clay.

In view of the interest that is taken at the present time in the influence on cement of elements other than those ordinarily determined, a simple, rapid and direct estimation of titanium will hasten development of views regarding this element in finished cement. Then, too, titanium may not always be neglected in the course of routine work's analysis unless its presence in negligible quantity is first established—indeed, in the course of the present investigation, a sample of clay from a cement mill was found which contained nearly one per cent of titanium dioxide whose presence had not been suspected. A ready, direct, quantitative method of estimating this component alone, will aid in deciding whether the percentage of titanium present in any given source of supply justifies the abandonment of the determination in every routine analysis. In the course of a complete analysis, as is well known, a part of the titanium contaminates the precipitate of silica, and the remainder is precipitated with the iron and alumina.

The steps in our procedure with argillaceous and other limestones were as follows:

- (1) Preliminary roasting.
- (2) Direct fusion with potassium pyrosulphate.
- (3) Solution by boiling in strong sulphuric acid, at least 1 part sulphuric acid to 4 parts water by volume.
- (4) Colorimetric comparisons by Weller's hydrogen peroxide method in this favorable strength of acid.

In the case of cement rock, one-half gram of the finely ground material is heated in a platinum crucible for five minutes over a bunsen burner, and then, for an equal time, with cover removed, over a moderate blast-lamp flame. The temperature should not be driven to a point at which the cement rock vitrifies. The necessity for this preliminary roasting is twofold—firstly, for the expulsion of carbon dioxide which would cause spattering in the subsequent fusion with potassium pyrosulphate; secondly, for the destruction of bituminous matter occurring with the rock, which if not com-

pletely burned and driven off at this point, causes serious, interfering darkening and discoloration in the subsequent solution, due to the action of sulphuric acid on organic matter. A moderate blast-lamp flame is sufficient, higher temperature leading to a vitrification of cement rock and causing it to adhere to the platinum crucible and preventing its ready grinding and thorough mixing with potassium pyrosulphate.

Nothing short of grinding the roasted material in an agate mortar with pulverized potassium pyrosulphate and returning the mixture to the platinum crucible was found to yield thorough-going action. In our experiments, inasmuch as we had no difficulty with subsequent solution, potassium pyrosulphate was used, although the sodium salt might be preferable. Fusion with the pyrosulphate is initiated with a comparatively high bunsen flame impinging on one side of the crucible, so that gases may escape through a liquid medium without causing the whole mass to lift or foam over. When the whole mass sinks into fusion, the burner is placed under the crucible with flame turned so low that a slight evolution of fumes of sulphur trioxide is just maintained. This temperature for one hour was found sufficient, two-hour fusions not leading to higher results. One-half hour fusions are satisfactory, provided that the grinding with pyrosulphate is very thorough. Attempts to obtain complete solution of titanium by treatment of the roasted material with hydrochloric acid and sulphuric acid instead of fusion with pyrosulphate, were found much more tedious and uncertain, necessitating previous vitrification of the material and long-continued action and evaporation of the acids on the steam bath.

The next step, that of solution of the pyrosulphate melt, is, as generally prescribed, a slow-going operation, requiring a solution by addition of cold water to prevent precipitation of titanium in the dilute sulphuric acid solution, and sometimes "cold" is italicized and the act of solution is prolonged for many hours, aided perhaps by stirring or by the addition of five per cent sulphuric acid. We found that much stronger solutions of sulphuric acid were positively beneficial for subsequent operations, and that in the act of solution they would allow us to dissolve the melt by boiling, with a gain in accuracy and at a saving of hours of time. Accordingly, the crucible and pyrosulphate melt are introduced into a breaker containing about 150 cc. of a mixture of 1 part concentrated sulphuric acid to 4 parts water by volume, i. e., about 30 per cent by weight. On heating, the melt soon loosens from the crucible, the crucible and cover are removed,

and the contents of the beaker heated to boiling until everything soluble is dissolved, twenty minutes being ample.

After cooling somewhat, which is hastened by standing in cold water, the contents of the beaker, soluble sulphates of titanium, iron, aluminum, calcium, magnesium, together with insoluble silica, etc., are transferred to a 200 cc. measuring flask, washing the beaker and making up to full measure with the 1 to 4 sulphuric acid. The 200 cc. volume in the measuring flask is allowed to come to room temperature, or a slightly lower temperature is preferable, as the undercooling allows of complete separation of calcium sulphate spicules which may crystallize from the solution at room temperature and thus forestall a delayed separation later in the analysis which would lead to inopportune cloudiness. When thus cooled, the content of the flask is shaken to promote impending separation of calcium sulphate spicules, and is then poured through a dry filter, rejecting the first 10 cc., into a 100cc. Nessler tube, until that measure is full. This solution of the unknown is now ready for comparison with solutions of known titanium content, best carried according to the colorimetric procedure of Weller, described by Hillebrand.¹

This method consists, in the main, simply in addition of hydrogen peroxide to solutions of titanium sulphate of unknown and known content and a comparison with eventual matching of the yellow colors produced.

Our solutions of known content were prepared from the customary double fluoride of potassium and titanium, $K_2TiF_6 \cdot H_2O$, which was found sufficiently pure, containing the equivalent of 30.74 per cent TiO_2 . A departure was made from the customary method of dissolving the fluoride, and, instead of evaporating nearly to dryness several times with strong sulphuric acid and dissolving in cold 5 per cent sulphuric acid, it was directly fused with potassium pyrosulphate and dissolved with boiling in 30 per cent sulphuric acid, in a manner very like the treatment of the cement rock.

The known solution is conveniently made of such strength that 1 cc. is equivalent to 0.00025 gram TiO_2 , corresponding to 0.1 per cent TiO_2 in the 0.5 gram sample of cement rock. An allowance may be necessary in the known solution for the very slight color produced by ferric sulphate in the unknown. This is customarily done by matching the iron color in the unknown with a solution of ammonium ferric sulphate in the known. We deemed it preferable to make a solution of 8.8 grams ferrous sulphate in 30 per cent sulphuric acid and to oxidize this solution with hydrogen peroxide, finally diluting with sulphuric acid to 200 cc. In this way, any effect that hydrogen peroxide may have on the corrective iron solution is provided for. As our iron solution contains excess of

hydrogen peroxide, it must, of course, be added in the proper quantity before the addition of standard titanium solution. As a rule, not more than from two to three cc. of the iron solution were required in cement rocks. The color of ferric sulphate is comparatively slight at any rate, and when the greatest accuracy is not sought the correction for its color in cement rocks may be entirely omitted.

When the iron correction factor is employed, the manipulation of the standards is: fill the 100 cc. Nessler tube nearly to the graduation with 30 per cent sulphuric acid, add the iron solution until the color produced matches that of the unknown, add from a burette the known TiO_2 solution, fill to the 100 cc. mark with 30 per cent sulphuric acid, add 1 cc. commercial hydrogen peroxide free from fluorides. With strong acid solution employed the titanium always shows its full color reaction without danger of reversion to less colored forms, and, furthermore, these strongly acid solutions continue to hold the titanium in solution in satisfactory condition for days, requiring only the addition of a drop or two of hydrogen peroxide from time to time.

The method as described above yields from ten to thirty determinations per day, depending on the supply of apparatus and the skill of the analyst. It may be as well to recall the fact that vadium shows a brown color with hydrogen peroxide which may be mistaken for titanium, or which may have a decided effect in deepening the color produced by titanium. Considering the wide occurrence of vanadium, it is necessary to guard against this possible error in every determination. This was done by adding a drop of hydrofluoric acid to the solution of the unknown after it had been compared with the standards. If the color developed by hydrogen peroxide is due to the titanium alone, it will be immediately discharged by the hydrofluoric acid; if due in any part to vanadium, there will remain a residual shade of color.

The following results were obtained in argillaceous limestones and other limestones representative of the Lehigh Valley cement district: and there are also included, a few determinations in limestones used in other cement districts, together with a determination in the standard sample of argillaceous limestone issued by the Bureau of Standards.

No.	SOURCE OF SAMPLE.	TiO_2
		Per cent.
1.	Alpha Portland Cement Co. Cement Rock. Quarries No. 1 and 2, Alpha, N. J.	0.21
2.	Alpha Portland Cement Co. Cement Rock. Quarry No. 3, Martin's Creek, Pa.	0.14
3.	Alpha Portland Cement Co. Cement Rock. Quarry No. 4, Martin's Creek, Pa.	0.17
4.	American Portland Cement Co. Cement Rock. Reliance Mill Quarry, Egypt, Pa.	0.14
5.	American Portland Cement Co. Cement	

¹Bulletin 305, U. S. Geological Survey, "The Analysis of Silicate and Carbonate Rocks."

Rock. Giant Mill Quarry, Egypt, Pa....	0.24
6. American Portland Cement Co. Cement Rock. Central Mill Quarry, Egypt, Pa..	0.24
7. Atlas Portland Cement Co. Cement Rock. Quarry No. 1, Northampton, Pa.....	0.18
8. Atlas Portland Cement Co. Cement Rock. Quarry No. 2, Northampton, Pa.....	0.19
9. Atlas Portland Cement Co. Limestone. Lerch Quarry	0.11
10. Atlas Portland Cement Co. Limestone. Anneville Quarry, Anneville, Pa.....	0.011
11. Atlas Portland Cement Co. Limestone. Franklin, N. J.....	0.007
12. Bath Portland Cement Co. Cement Rock. Bath, Pa.	0.14
13. Bath Portland Cement Co. Limestone. Bath, Pa.	0.01
14. Bonneville Portland Cement Co. Cement Rock. Siegfrieds, Pa.....	0.21
15. Catskill Portland Cement Co. Limestone.	0.10
16. Dexter Portland Cement Co. Cement Rock. High stone. Nazareth, Pa.....	0.20
17. Dexter Portland Cement Co. Cement Rock. Low stone. Nazareth, Pa.....	0.21
18. Edison Portland Cement Co. Cement Rock. Stewartsville, N. J.....	0.15
19. Hudson Portland Cement Co. Limestone. Hudson, N. Y.....	0.07
20. Iola Portland Cement Co. Limestone. Iola, Kansas	0.003
21. Lawrence Portland Cement Co. Cement Rock. Creek Quarry, Siegfrieds, Pa....	0.24
22. Lawrence Portland Cement Co. Cement Rock. Canal Quarry, Siegfrieds, Pa....	0.21
23. Lehigh Portland Cement Co. Cement Rock. Quarry No. 1, Ormrod, Pa.....	0.17
24. Lehigh Portland Cement Co. Cement Rock. Quarries No. 2 and No. 3, Ormrod, Pa..	0.14
25. Lehigh Portland Cement Co. Cement Rock. Quarry No. 1, West Coplay, Pa.....	0.15
26. Lehigh Portland Cement Co. Cement Rock. Fogelsville, Pa.....	0.18
27. Northampton Portland Cement Co. Cement Rock. Stockertown, Pa.....	0.25
28. Vulcanite Portland Cement Co. Cement Rock. Quarry No. 1, Phillipsburg, Pa..	0.26
29. Vulcanite Portland Cement Co. Cement Rock. Quarry No. 2, Phillipsburg, Pa..	0.16
30. Whitehall Portland Cement Co. Cement Rock. Cementon, Pa.....	0.13
31. Bureau of Standards, Washington, D. C. Standard Argillaceous Limestone.....	0.226

Obligation is expressed to the cement companies who in all cases kindly complied with a request for samples for this investigation.

A MODIFIED METHOD FOR THE DETERMINATION OF SALT IN BUTTER.

By J. M. BARNHART.

Department of Dairy Husbandry, University of Illinois.

In the analysis of butter, salt is usually determined either by the direct (1) Bul. No. 107 (Revised) U. S. Bu. Chem., p. 124. 2-Ibid method (1) or the ash extract method, (2) as they may be called. In the direct method, the salt is extracted by means of hot water directly from 5-10 grams of the butter in a separatory funnel. The extract is collected in an Erlenmeyer flask and titrated with a silver nitrate solution of known strength, using potassium chromate as the indicator. In the ash extract method, the salt is extracted from the residue of the ash determination and the extract titrated as in the direct method.

While the direct method is usually accurate, there are real objections to it. The accuracy of this method is sometimes impaired by losses due to accident in transferring the melted butter from the beakers to the narrow mouthed separatory funnels. Furthermore, unless special funnels are used, there is always danger of loss from spattering of the melted butter from the funnels when the stoppers are removed after the agitation of each fractional extraction. The passage of fat globules into the extract is another source of error that must be avoided. Another objection to this method is the amount of time required for the weighing of the butter for each determination and the cleaning of beakers, separatory funnels, and Erlenmeyer flasks.

The objection to the ash extract method is the danger of loss of chlorine through volatilization when ignition is made in the ash determination. Unless extra precaution is taken the percentage of ash reported will be too high at the expense of the salt content.

DESCRIPTION OF MODIFIED METHOD.

During the course of an extended investigation in dairy manufactures involving the analysis of a large number of samples of butter, the writer has devised the following modification of the above methods for the determination of salt in butter.

The salt is extracted from the residue which is left from the indirect fat determination (3) by washing it with boiling hot water. Suction is applied to 3-ibid, p. 123, the Gooch, in a manner described below, to remove the washings by filtration and filtrate of about 100 cc. collected in a 150 cc. beaker. When cold, the beaker is slipped into a porcelain jar (a small white cheese jar is suitable for this purpose) to insure a white background, and titrated as usual.

In order to apply the necessary suction to the Gooch, and to collect the filtrate in a beaker, it became necessary to devise a special suction flask. This flask was made from the top of a 6-inch vacuum dessicator and the lid of an ordinary dessicator. The lid of an ordi-

nary dessicator, mounted on a suitable base, forms the bottom of the flask while the upper section of the vacuum dessicator forms the top. Figure 1 shows the flask fitted up. A two-holed rubber stopper (S) connects the filter funnel and the filter pump with the suction flask. A T tube (T) and pinch cock between

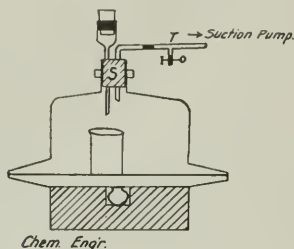


Fig. 1.

the flask and pump allow the slow release of the vacuum which prevents loss of filtrate that a sudden rush of air into the flask would cause. With the vacuum released and the Gooch removed, it is an easy matter to lift the top of the flask and remove the beaker and contents.

An ordinary vacuum dessicator might have been used for this purpose but the depth of the lower section makes it inconvenient to remove small beakers without danger of accident. The results obtained by this method show it to be at least as accurate as the other methods for the determination of salt in butter. The direct method may be regarded as the most accurate of the other methods in the hands of the average chemist. The following table is a comparison of the modified method with the direct method:

TABLE I—A COMPARISON OF THE DIRECT AND MODIFIED METHODS FOR THE DETERMINATION OF SALT IN BUTTER.

Sample Number.	BUTTER.	
	Direct method Per cent Salt.	Modified method Per cent Salt.
1	1.30	1.27
2	1.73	1.70
3	2.58	2.61
4	1.43	1.44
5	2.52	2.54
6	1.43	1.40
7	1.74	1.78
8	1.45	1.47
Average	1.77	1.78

From the above data it will be seen that the modified method compares favorably with the direct method. The greatest variation is 0.04 per cent, which is sufficiently close for duplicates in an ordinary salt determination in butter. A comparison of the averages for the eight samples analyzed by the two methods shows a difference of but .01 per cent.

After a thorough trial extending over a period of six months, the author believes that the modified

method is a practical one for the determination of salt in butter. It possesses the good points of both the direct and ash extract methods without their shortcomings. It is much shorter than the direct method and is as accurate. It has the advantages of the ash extract method in that it requires the weighing out of only one sample of butter for the determination of moisture, fat, and salt.

SUGGESTIONS FOR THE CONSTRUCTION OF CHEMICAL LABORATORIES'

By AUGUSTUS H. GILL.

Massachusetts Institute of Technology.

General Construction.—For a chemical laboratory there is probably nothing better than the so-called slow burning or mill construction. While lath and plaster may be more handsome from an artistic point of view, yet it suffers from the serious disadvantage that the ceiling becomes disintegrated from the acid fumes, with the inevitable result that it drops into the quantitative determinations, to their ruin, or hangs in festoons or fragments that are anything but artistic.

Walls.—The Walls should, if possible, be faced with white glazed brick; if this be prohibitive on account of cost, at least where they are exposed to view. In place of this, possibly pressed yellow brick, white "silica" brick, or ordinary red brick painted white may be employed. The paint employed should contain no "white lead," but may be sublimed lead ($PbSO_4$), barytes or zinc white, or preferably a mixture of these in about equal proportions or lithopone. Some of the so-called cold water paints have been used with fairly good success. They may turn black in damp weather, but usually return to their white color when dry.

Floors.—If care be taken to keep the joints tight between the walls and floors there is probably nothing better for a laboratory floor than asphalt. The writer knows of some laid twenty-five years ago that have required no outlay for repairs and are apparently good for another quarter century. Laboratory desks and heavy apparatus should be supported on a broad framework to prevent them from sinking too deeply into it. The asphalt, as wood floors, should be laid upon a heavy grooved and tongued wooden floor with paper between. These floors can be supported upon double wooden beams or upon iron beams kept well painted with a metal varnish coating. Rift hard pine, birch or maple, when carefully selected and laid, makes a good floor, particularly if kept well oiled. This has the disadvantage of making it slippery. It is of course not as tight as an asphalt floor.

Ceilings.—Too much attention cannot be paid for their construction, as the writer knows of three large new laboratory buildings in which a more or less constant precipitation of sawdust, paint and plaster is taking place upon the floor below, because of an over-

'From *Science*, Oct. 22nd, 1909.

sight in this particular. This, in one case, is due to the application of a coldwater paint, which is scaling off from the ceiling when the floor above is walked upon. In the other two cases sufficient care was not taken to sweep clean the first layer of floor boards before laying the second. All this can be obviated by putting in a ceiling of matched boards *after all floors have been laid*. It should be finished with shellac or coach varnish. Something of a pitchy or resinous nature should be used (and yet contain no common rosin, as that is far from durable), rather than a paint which can peel or flake off. This should be borne in mind in all overhead construction. As has been said, plaster of any kind is inadmissible in a ceiling on account of its disintegration by acid fumes. Cement is no better, as in one laboratory of which the writer knows a cement ceiling began to flake off within about six weeks after occupation.

Fire Walls and Protection.—The building should be subdivided into areas of suitable size by fire walls extending from top to bottom; all apertures in these walls should be guarded by automatic fire doors. The library, if there be a departmental one, should be housed in a fireproof room and also be protected from being flooded by leaks on the floor above. The more dangerous laboratories—the organic, the oil testing and those below or adjacent to the library should be rendered safer by the installation of sprinklers. Somewhere in the building there should be a fireproof room for the distillation of inflammable substances. In addition to fireproof stairways a sufficient quantity of outside iron fire escapes should be provided and the exits thereto carefully indicated and kept unfastened. Inch rubber fire hose with nozzle should be provided in each laboratory. Rubber is better than linen or any other collapsible type of hose, in that it does not kink and thus can be taken through doorways when there are self-closing doors without checking the stream of water. A number of small hose are better than large hose in the hallway, in that they are more accessible, and if used, do not deliver such a torrent of water as to occasion a greater loss from water than from the fire itself. Pails of sand with scoops are very efficient and should be found in every laboratory. No money, however, should be wasted on the purchase of "dry powder fire extinguishers," of which Dr. Freeman says "we recommend that they be thrown into the rubbish heap."²² If these are wanted they can be easily made by filling tin tubes with two or three pounds of "anchor dust" or waste bicarbonate of soda. In the organic and oil testing laboratories or any other where the fire risk is unusual, in addition to these safeguards above mentioned and automatic sprinklers, some type of portable chemical fire extinguisher should be included. This, as is well known, employs carbonic acid generated by the action of sulphuric acid upon baking soda to throw a stream of carbonated water about, which is especially effective in tar and chemical fires.

A large douche bath with quick opening valve has been found very convenient in extinguishing fire on a student's clothing. This is merely a rose, or better a flat hollow disk a foot in diameter with concentric slits in it, through which the water issues in a shower; it is set seven feet from the floor.

Heating and Ventilation.—The so-called "plenum system" for the general heating and ventilating of a laboratory building may be said to work fairly well, but it must be supplemented by steam radiators and by independent fans, one or more for each laboratory, drawing upon the hoods. These can be placed in the laboratory or, better, on the roof. The hoods in addition to having the usual outlets at the top should be provided with an outlet at the bottom, as most of the gases and vapors of which the chemist wishes to be rid are heavier than air. Besides the fan draft in the hood the flue should be so arranged that a good sized Bunsen burner can be kept burning in it for use when the fans are not running.

Hoods.—These can in general be disposed of about the laboratory walls and be constructed of wood, pine, white wood, cypress or "asbestos wood" or "asbestolith" with wooden or asbestolith sashes. Where the material is exposed to steam, hot air, or unusually corrosive agents, they perhaps can be made of glass, wired glass, admitting of large panes set in lead-covered sashes.

Iron settings for the glass, unless kept well painted, are not to be recommended. Possibly these sashes may be omitted, and the hoods built after the manner of show cases of plate-glass show windows, by drilling and holding the glass plates in position by angle irons kept well painted with a pitchy "paint." The backs and tops of the hoods can be lined with the same material, where wood is inadmissible, and it is desired to secure freedom from scaling from the brick walls. The use of hoods extending over each desk, as in Edinburgh, is of doubtful expediency and renders the laboratory dark and fills the ceiling up with their exit pipes. The use of small low hoods at each desk would seem to render the piping system complicated and expensive. Except in very special cases the necessity of an individual hood close at hand is not very great. The bottoms can be made of concrete or wire lath, tile or soapstone, and the hoods should not be more than 18 inches deep. The ducts from the hoods can be made square or rectangular, of the wood or the asbestos compositions mentioned. If of wood they can be grooved and tongued, glued and nailed together and varnished. If made of iron they should be painted with an asphalt or pitchy paint, as "chrysolite" (Solway Process Co.). Aluminum paint is not found to protect iron as well as has been claimed for it.

Laboratory Desks and Lockers.—So far as the writer's experience goes, the responsibility for their selection lies usually with the architect, and it is common experience that architecture and chemistry do not

²²"On the Safeguarding of Life in Theaters," p. 87.

"mix"; that is, good architectural students are oftentimes deficient in chemistry.

Quartered-oak desks and alberene stone tops seem almost as much out of place amid the fumes and acids of a chemical laboratory as dress suits for the students. Even a casual visitor cannot help having a pang of regret to see a fine quartered oak panel ruined by the attack of sulphuric acid or caustic soda. Speaking from wide observation and the experience of others, the writer is convinced there is no better (and in the long run cheaper) material for the tops of ordinary laboratory desks than wood. Tiling is always uneven, lead is untidy and expands but does not contract when heated, glass cracks, and all are cold to the touch. For the tops of laboratory desks or tables the following woods have been found to give good satisfaction: Northern pine, whitewood, cedar and California redwood. These may be finished with equal parts of linseed oil and turpentine, or, better, filled with aniline black made in the pores of the wood, according to the following procedure: Apply to the wood solution one, and after it has dried in, solution two: Solution I, 100 grams aniline hydrochloride, 40 grams sal ammoniac, dissolved in 650 cc. of water. Solution II, 100 grams copper sulphate, 50 grams potassium chlorate, dissolved in 650 cc. of water. Oak, ash, or cypress cannot be recommended, the former two because they shrink too much and the last because it is very splintery. If the tops are made of two-inch stuff they can be planed down from time to time and even turned over, when one surface is too far gone for planing. Such tops have been known to last with constant usage in an organic and analytical laboratory for nearly thirty years. These plank tops should be made of lumber as wide as possible and be carefully jointed and well glued together. When properly done it is rare that the glued joint starts. From some laboratories which the writer has seen it would not seem advisable to build the tops of narrow seven-eighths inch floor boards even when fastened to a second seven-eighths inch top; the joints open and the boards warp and curl making a very undesirable, uneven surface.

Desk Hardware.—For locking the desks, iron hasps and screw eyes and heavy padlocks have given excellent satisfaction even with freshmen, for twenty-five years' constant use. These locks² are bronze throughout, with brass or bronze springs and six secure levers, master-keyed, with changes permitting at least four hundred in a series; they are circular, except for the shackle, and about two and one-fourth inches in diameter and cost about a dollar each. They should be oiled annually with a light non-gumming petroleum spindle oil. Padlocks have the advantage over mortise locks, keyed or keyless, in that if they fail to open the screw eye can be cut with a blacksmith's bolt cutter, the padlock removed and the cut screw eye replaced by another. The damage to the desk is nothing

compared with that incident to forcing a drawer or hammering the lock loose or off by a punch on the round key-hole standard. They have the additional advantage that they, being laid on their side, in the drawer when not in use, or not exposed to the corrosive action of chemicals spilt upon them. These run down the mortise lock around the bolt and levers and stick them fast. Their sole disadvantage, as against combination locks, lies in the loss of the key. The losing of keys can be largely prevented by requiring the use of key chains attached to the bunch of keys and also by informing the student that they are charged one dollar each if lost. They have the advantage that they are much more easily opened, while if the combination be forgotten the instructor has to search it up in the records. Unless the combination on each lock be changed annually, an elder student, a sophomore, for example, would have access to the desk which he used as a freshman, which is now occupied by another student, a serious disadvantage. The changing of several hundred combinations annually is no trifling task. Hardwood knobs are to be preferred to metal knobs or handles. The Fogg adjustable ball catch with the ball on the *standing* part of the desk has given excellent service. Iron hinges are apparently as good as brass and are cheaper.

Piping and Drainage.—All pipes and drains should be arranged so that every foot can be easily rendered accessible for inspection and repairs. This can be brought about by the "top system" of pipes and drains on the desks and these connected with the main system under platforms running along one end of the desks. Or the piping can be arranged upon the back of one line of desks and the other line, which is movable, backed up to it. Iron piping should be used as far as possible, the outside being painted with a pitch or asphalt paint. Lead lined pipe instead of lead would seem to be satisfactory for suction. For peaty service waters, black pipe fills up rapidly with zooglea, crenothrix and iron rust. This can be avoided to a large extent by the use of galvanized iron or lead-lined pipe. For drainage the lead-lined or even plain wooden troughs kept well painted with thin coats of asphalt have given good satisfaction. They are much to be preferred to lead pipes, which continually give trouble from clogging. In concrete construction the writer has these troughs replaced by trough-like depressions made in the floors and lined with asphalt. Care should be had to make these of sufficient capacity and fall; they are covered with slate or cast-iron slabs. The vertical drains should be constructed of hard baked Akron tile or better yet, chemical pottery, and the joints made with cement or possibly with the same material as the asphalt floors. These vertical drains can either be in the elevator well or in a square space in the wall, it being closed with doors so that they too, are readily accessible. Individual traps and vents are not needed in the various laboratories, but the whole system should be effectively protected by traps in the

²Made by the Miller Lock Co., Philadelphia, Pa.

basement. For sinks the ordinary round stoneware wash bowl may be used. This is made with an overflow, and instead of the usual brass fitting at the bottom a porcelain tube two or three inches long projects from it, carrying eyelets at the top on either side of the bowl. The tube fits down into a piece of lead pipe two feet long which empties into the trough on the back of one line of desks. This lead pipe is supported at the top by the eyelets just mentioned. These pipes can then be easily replaced by the janitor, the services of the plumber not being needed. Each laboratory should be provided with valves so that the stream, water and gas can be shut off from it without disturbing another room. The gas valve should be placed near the exit so that it can be closed nightly and diminish the danger from fire.

NEW DEVICE FOR ELECTROLYTIC ASSAYS.

BY F. O. BACON.

The greatest annoyance that the chemist experiences in the electrolytic determination of metals is the failure of the assay at the time when it should be finished. This failure is usually due to a weak current if he is using batteries, or to an intermittent current if he is relying on a direct current light line from which the current may be shut off for a few minutes at some time during the progress of the assay. In the case of batteries he finds it impossible to finish the assay for lack of current of proper strength, while in the case of light lines he finds that the current has been off just long enough to allow his copper to redissolve. In either case, blackened cones or partially precipitated metals make the work unsatisfactory.

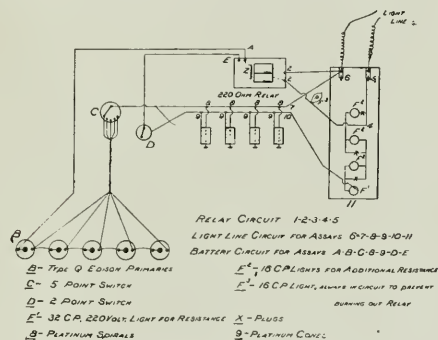
About two and one-half years ago the writer conceived an idea to overcome the loss and annoyance mentioned, by devising an apparatus which would make use of either batteries or light line, using the former when the latter was intermittent and the latter when the former was weak. The scheme, in brief, involves the use of an ordinary telegraph relay, running the light line through the coils when the circuit is on, and connecting the batteries through the local side of the relay, so that when the light line fails it releases the armature and completes connection through the batteries, thus insuring a steady current from one source or the other without the expense of a storage battery.

Reference to the accompanying diagram will serve to make the explanation clear. Three currents are involved in the operation of the apparatus; first, the current from the light line operating relay; second, the current from the light line operating the assays; and third, the current from the batteries operating the assays. The two latter are, of course, not in operation at the same time.

The current operating the relay passes just like a similar current through a drop light, through the

points 1-2-3-4-5, and holds the armature of the relay against the coils and away from the local side of the relay—A and E being the local wires connected through the base of the relay and running to the batteries and assays as shown. The circuit 1-2-3-4-5 is in no way connected with the assays, merely serving to keep the battery circuit A-B-C-8-9-D-E broken while the circuit from the light line 6-7-8-9-10-11 is operating the assays.

The current from the light line operating the assays passes through 6-7-8-9-10-11 and then through any number of lights required for resistance, as at F¹ and F², and then out through the point 5. While the light line is working, it being so much more powerful than the batteries, the armature on the relay is held against the coils and the battery circuit is broken; but the instant the light line fails, the spring on the relay pulls the armature over and the contact points Z on the local side complete the circuit through the batteries A-B-C-8-9-D-E, and no interruption of circuit results to spoil the assays.



Sketch Showing Arrangement of Electrolytic Apparatus and Connections.

The amount of resistance to be used is dependent on local conditions. For four cathodes we use a 32 cp. 220 volt (direct current) light for resistance as shown at F¹. Additional resistance is provided for by three 16 cp. lights shown at F², and cut-out plugs shown at x. The four resistance lights and the cut-out plugs are placed on a piece of hardwood 2 in. x 4 in. x 18 in. with all connections soldered and wrapped with tape.

It is necessary to make a minor change in the relay in order to have it operate satisfactorily. On the coil frame there is one contact point which must be removed in order that the armature can be held close to the coils and not by the point. This point is in the frame; the other point Z on the local side is required to complete the battery circuit A to E.

In order to avoid the possibility of burning out the relay due to unsteady current, it is necessary to have one 16 cp. light in the relay circuit as shown at F². This resistance is in the circuit constantly. Our relay has burned out but once in the past two and one-half

years, and on this occasion there was no resistance as shown at F². It is also well to have a piece of glass under the relay to protect the woodwork from possible danger of fire should the relay burn out.

The relay used in our laboratory is a J. H. Bunnell & Co., New York, 220 ohms resistance. The balance of the equipment consists of five type Q Edison primary cells; a 5-point switch at C, used to cut in one or all of the Edison cells; a 2-point switch at D, to break the battery current if desired; lights and cut-outs as shown at F and X.

We regularly use the light line for our work, but occasionally it fails just long enough to allow the copper to dissolve from the cathode. When the current comes on again it precipitates enough copper to make it impossible to know how long it will take to finish the assay; but by using the batteries in connection with the light line the work is complete when expected. When the batteries are new it is usually sufficient to set the 5-point switch C so that but three of the cells are in the circuit. As the current is found to weaken, all five of the cells may be thrown into the circuit ready for a possible failure of the light line. We have been compelled to renew our batteries but once a year since using this system, and have had no lost assays through failure of light line or batteries.

The expense of this equipment is comparatively slight and the writer believes that \$25 should cover the cost of equipment and labor. If desired, the entire apparatus can be enclosed in a case about 4 feet long and 5 high.

As far as the writer is aware this idea has not been put into operation elsewhere, but it is believed that where the conditions are favorable, i. e., a direct current light line available, and where the work demands it, the scheme will be found useful.

In the course of an address, Prof. M. T. Bogert, president of the American Chemical Society, stated: "In the United States the average thickness of locomotive boiler scale is one-sixteenth of an inch. This means a loss of at least thirteen per cent in fuel efficiency; for an eight-inch scale this amounts to twenty-five per cent, and for a half-inch sixty per cent. Taking one-sixteenth inch, then, as the average boiler scale, this means for our fifty-one thousand locomotives alone, a total annual loss which may be estimated conservatively at fifteen million tons of coal. The use of properly treated water in the boilers reduces the coal consumption and, by decreasing the amount of repairs and prolonging the life of the boiler, reduces also the demand for iron."

The Formofume Co. has just completed the establishment of its factory at Michigan City, Ind. The company manufactures the formofume in-door air moistener, formofume liquid disinfectant and disinfecting devices.

"CORK METAL."

By F. J. WILLOTT.

At one of the recent aeronautical exhibitions, samples of a metal were shown under the name of "cork metal," which was said to be 40 per cent lighter than aluminum, and to have numerous other properties which should make it a rival of the latter.

Great secrecy was maintained as to the nature of this wonderful metal, but its properties were such as to rouse my interest, as a consequence of which I have submitted it to chemical analysis.

In appearance the metal resembles very strongly the alloys known as magnalium. The surface presents a lustreless whitish grey color, both sheets and bars showing the scorings and scratches so frequently found on badly rolled or drawn aluminum. Careful analysis gave the following result:

	Per cent.
Aluminum	0.04
Iron	0.017
Zinc	0.48
Sodium	0.21
Magnesium	99.30

It will be seen therefore that essentially "cork metal" is nothing but magnesium to which a small amount of zinc has been added. Whether this latter has been purposely introduced or, as is more probable, is merely present as an impurity, I am unable to say.

As the metal evolves hydrogen when immersed in water, I found it necessary to use organic solvents for the determination of the specific gravity. In alcohol this was found to be 1.762, thus confirming the conclusion that cork metal is, in fact, magnesium.—*Chem. News.*

THE ANTIMONY INDUSTRY IN MEXICO.

The Mexican antimony industry was developed by M. Elsasser, an American engineer, who for many years controlled the market. Later he became associated with the Cookson interests of London and later sold out to them. A smeltery for the production of star antimony was installed at Wadley on the National Railroad in the northern part of San Luis Potosi about 1000 and practically all of the Mexican ore is now treated there and shipped abroad as metal.

The smeltery is controlled by the Cookson interests, which also have mines or contracts at Charcas, and Catorce in San Luis Potosi, and control the most important antimony deposits in other parts of Mexico. Most of the production is from mines controlled by this interest, as but very low prices are offered for independent ores. Recently several German buyers have appeared in the Mexican field and American interests were attracted there before the Payne tariff increased the rate of duty on antimony ore. There are abundant deposits of antimony in Mexico.—*Eng. and Min. J.*

METALLURGY

THE HEAT TREATMENT OF SPRING STEEL.*

BY LAWFORD H. FRY.

The following account contains the essentials of a paper by Lawford H. Fry, representative of the Baldwin Locomotive Works, giving results of tests made at the works in 1907.

The specimens examined were of basic, open hearth steel, having the following composition:

	Per cent.
Carbon	1.01
Manganese	0.38
Phosphorus	0.032
Sulphur	0.032
Silicon	0.13

HEAT TREATMENT.

The critical point of the steel was found to be 1360° F., as determined with the aid of a magnet. Previous experience has shown that the steel for annealing should be heated to 40° or 50° above the critical temperature, and 50° or 100° above for hardening, the exact temperature being determined by the size of the work and the effectiveness of the cooling bath. The temperatures used in the present investigation were as follows:

	Deg. F.
For annealing.....	1,400
For quenching in oil.....	1,450
For quenching in water.....	1,425

The only variables in the heat treatment were in the heats at which the temper was drawn and the mode of quenching. The specimens were heated in a lead bath, so constructed as to secure control and uniformity of temperature. The lead was contained in a cast iron pot placed in a circular, brick-lined furnace. Six burners, uniformly spaced, admitted a gas blast at a tangent with the brick walls, so that the flame rotated around the lead bath without impinging upon it at any point. The temperature of the bath was registered by means of a Bristol electric pyrometer.

For annealing the test pieces were plunged into the bath, the lead being heated to 1400°, and kept at that heat for two hours, and then allowed to cool naturally with the furnace. The time of cooling was 14 hours, the pot being covered.

For hardening the test pieces were heated to the above temperature and then quenched: first, in oil at a temperature of 80°; or second, in pure, running water at 60°. The oil used had a fire test of 600° or over and a specific gravity of not less than 25° B. at

60° F. While being quenched the test pieces were agitated until cooled to the temperature of the bath.

For drawing the temper, up to 600° the test pieces were placed in an oil bath heated by gas, the temperature being registered by means of a thermometer; for drawing the temper above 600° the pieces were heated, as above, in the lead bath. After the temper was drawn to the desired temperature the pieces were taken out of the bath and left to cool in the air.

METHOD OF TESTING.

All the specimens were tested transversely. They were placed on supports 12 inches apart and the loads applied in the middle. The specimens were 1 inch in diameter with a uniform, circular cross section. The blocks upon which they were supported during the testing were of tool steel, rounded to the shape of the specimens and carefully seated into a forged steel base. With all the precautions it was found that the blocks would cut into the specimens one or two thousandths inch. In order to offset this error in the measurement of the deflections the specimens were subjected, before the load was begun, to the repeated application and release of a load which stressed them to about two-thirds of the elastic limit. The load was applied and released often enough to seat the specimen on the supports without giving it a permanent set. When the specimen was seated, the test proper was begun, and the height and deflections of the bars measured with an inside micrometer, measuring to 0.00001 inch. The points of measurement were the middle of the specimen and the center of the steel support base. The deflections were increased by deflections of 0.0005 inch at a time, and the loads measured for each increment of deflection. No record was obtained for permanent sets above the elastic limit, since the specimen was not released after the test was begun, this having been found to be the most accurate method.

COMPUTATION OF RESULTS.

The elastic limit is taken as that point at which the ratio of deflection to stress ceases to be appreciably constant, and the deflection begins to increase at a faster rate than stress. The fiber stresses, elastic limit and modulus of elasticity were calculated from the usual formulae for a simple beam supported at both ends and loaded at the middle, as follows:

$$S = \frac{Wlc}{4I} \dots (1) \quad f = \frac{WP}{48EI} \dots (2) \quad E = \frac{WP^2}{48fl} \dots (3)$$

and combining (2) and (3)

$$f = \frac{SP^2}{12Ec} \quad E = \frac{SP^2}{12fc}$$

where

S = maximum fiber stress in pounds per sq. in.

*Paper read before the Internal Society for Testing Materials at the Copenhagen Congress, September 7 to 11, 1909

W = load in middle, in pounds.

l = span, 12 ins.

I = moment of inertia of cross section $\frac{\pi d^4}{64}$ or a round section.

f = deflection in middle, in inches.

E = modulus of elasticity.

c = distance of neutral axis to outermost fibers = $\frac{d}{2}$.

d = diameter of test piece, in inches.

THE MODULUS OF ELASTICITY.

The results of the tests show that the modulus of elasticity is practically constant, and practically independent of the heat treatment given. The modulus of elasticity is difficult to determine accurately, on account of the precision required in measuring the deflections and loads, which vary by very small amounts. It is to be noted that any error in the measurements is likely to make the value of the modulus of elasticity smaller than it should be. The modulus of elasticity

CONCLUSIONS.

Steel containing 1 per cent of carbon, when quenched in cold water from above its critical point, is usually too hard and brittle to be used for making tools and springs. According to the theory of hardening steel the two ways of modifying this hardness are: First, to allow some of the carbon fixed in the "hardening" form by quenching to change to the "annealing" form by reheating the steel above 400°. The higher the reheating or "drawing of the temper" is carried the softer the steel becomes. The second way is to quench with a bath having a lower heat conductivity. The slower the steel is cooled from above the critical point to about 400° the more carbon is allowed to change to the "annealing" form, and the less the steel hardens. The hardness of the steel may be modified by the second method without "drawing the temper" after the hardening. The two methods may be used jointly.

These points are illustrated in the tests. The higher

TABLE SHOWING RESULTS OF TESTS ON SPRING STEEL.

No. of tests.	Heat treatment (Deg. F.).	Elastic limit	Diameter of test piece			Breakage
		pounds per 84-in.	Modulus of elasticity.	inches.	of moment of inertia.	
17	Annealed in lead at 14000.....	78,500	27,550,000	0.991	0.04730	Did not break
11	Hardened in oil at 1450, drawn to 560.....	137,500	28,700,000	1.000	0.04909	Did not break
14	Hardened in oil at 1450, drawn to 500.....	160,400	27,150,000	1.000	0.04909	Did not break
19	Hardened in oil at 1450, drawn to 400.....	177,600	29,080,000	0.991	0.04730	Did not break
12	Hardened in oil at 1450, not drawn.....	187,400	28,610,000	0.993	0.04772	Did not break
16	Hardened in water at 1425, drawn to 1050....	180,700	28,070,000	0.997	0.04850	Did not break
13	Hardened in water at 1425, drawn to 900.....	233,900	28,860,000	0.998	0.04870	Did not break
15	Hardened in water at 1425, drawn to 750.....	240,800	29,220,000	0.994	0.04790	0.744
20	Hardened in water at 1425, drawn to 600.....	210,800	30,420,000	0.991	0.04730	0.175
18	Hardened in water at 1425, not drawn.....	212,000	29,960,000	0.991	0.04730	0.175
Test pieces 17, 11, 14, 19, 12, 16 and 13 did not		break under a deflection at the middle of 1.1 inch.				

is the ratio of the stress to the strain, or in this case,

$$E \text{ varies as } \frac{\text{stress}}{\text{deflection}}$$

Now, all measurement of deflection have a tendency to be too large, and consequently, the values found for E have a tendency to be too small, because the blocks and base on which specimens rest are compressed to a certain amount by the loads imposed, and if not perfectly fitted the blocks take a certain set which, together with the compression of the support, is measured with the true deflection of the test pieces and added to the true deflections in all the computations. Also, the softer the test pieces the more difficult it is to prevent the supports from denting them. The values obtained for the modulus of elasticity are from 27,150,000 to 30,240,000. It would seem that the higher values are more probably correct, and that the true modulus of elasticity lies between 29,000,000 and 30,000,000, and is probably not affected by the heat treatment.

the temper is drawn after hardening the lower the elastic limit falls; also, a lower elastic limit is obtained with the test pieces quenched in the bath having the lower heat conductivity, viz., oil. The tests show that the elastic limit of 1 per cent carbon steel can be made to vary from 78,500 to 340,000 pounds per square inch by changes in the heat treatment, and that very small changes in the "drawing of the temper" are sufficient to affect the elastic limit of the steel.

Saltpetre deposits occur in Chile throughout an area of 22,500 square kilometres, or 8,687 square miles. This area is but 18 to 20 miles wide, and stretches along the Pacific Coast for over 450 miles. The deposits of *caliche*, or soda nitrate impregnation, are irregular, both as to extent and richness, but the total resources of the region are quite unknown. Estimates place the total available *caliche* at 340,000,000 tons, which would yield about 2,500,000 tons of saltpetre. At the present rate of exportation this quantity would last 136 years.

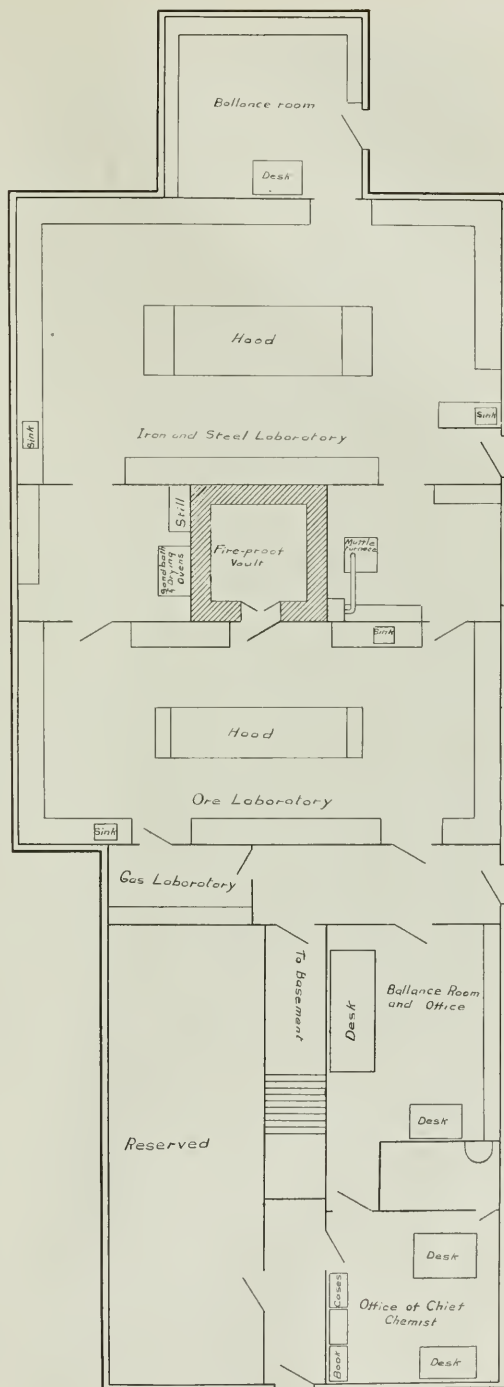
THE CHEMICAL LABORATORY OF THE DUQUESNE STEEL WORKS.

BY HENRY WYSOR.

Every imaginative chemist has in his mind an ideal laboratory. This visionary, chemical workshop is, of course, a departure from any existing types, the defects of these having been eliminated. There are but few who hold that good results may be obtained regardless of environment; there are many who have not "fixed up" to the extent which they ought or intend; the youngest know what the conditions should be; all know that the full attainment of those conditions is impossible. As a matter of fact, more depends upon the chemists's ingenuity and care in arranging the interior than upon the actual construction of the building in which the work is to be done. Structural mistakes existent may be accounted for largely from the fact that many of the laboratories were not designed by those who fully understood the requirements; the shortcomings may be offset by practicable additions or alterations. Better let the chemist's time and energy be expended in improving quarters, if that be feasible, for haply the air castle must remain in the air.

Those who are familiar with the different departments of the iron and steel plants in this country know what the typical laboratory is. Its exterior does not attract; its interior repels. At many places the clerical and drafting forces have elegant quarters, while the chemists must be or are content with a shabby building and furnishings in keeping. This is more common with the older concerns that have not been so fortunate as to suffer the ravages of a fire in the region of the chemical laboratory. Furthermore, due regard has not always been paid to the location of the laboratory. It is often so close to the mill operations that the chemists' work is seriously hampered by vibrations and dust. Against those that merit reproach, however, there are some shining exceptions, and it is the purpose of this article to call attention to one of these, not to criticise any in particular or to discuss chemical laboratories in general. The article is made brief lest it be not read, and the motive for the choice of subject is given unhesitatingly and unreservedly. The fact that the condition of the average work's laboratory in America is not compatible with the acknowledged importance of chemists' services nor with the advance which has been made in the science of chemistry warrants a plea for the betterment of their condition. Being a teacher of analytical chemistry the writer would point to that which dignifies the profession, with the hope that such an example from practice may inspire and influence some of those in whose hands the future of the business lies.

The point, above made, of utilizing the material at hand is well amplified in the history of the Duquesne Steel Works laboratory. As a department in one of



Plan and General Arrangement of Duquesne Laboratory.

the great iron and steel plants it has stood a time test, and proved its efficiency in service.

The accompanying drawing shows the plan and general arrangement of the Duquesne laboratory. It occupies practically the entire ground floor and basement of a large, frame building, which formerly contained the general offices of the works. This affords a total of eleven rooms. All of the laboratory proper is on one floor, the basement rooms being used for storing heavy chemicals. A glance at the sketch will show the easy access to all of the working rooms, and the convenient arrangement of the desks, hoods, water, etc. The interior walls are finished with chemical-resisting paint, and the floors are covered with linoleum. All the rooms are well lighted and ventilated.

The average daily requirement of the chemical force is about as follows: Analysis of one to six ores, one or more each of coal, coke and limestone, six samples of blast furnace slag, upwards of fifty of pig iron and sixty of steel, representing the products of six blast furnaces and thirty-two open hearths, and blast furnaces, producer and flue gases. In addition to the daily work the chemists must be prepared to report on the numerous mill products and steel works materials, such as refractories, mill cinders, alloys, paints and oils. The standards are, without exception, made at home.

Mention is here made of the accessories to the laboratory. The sample house, which is situated near the blast furnace stock yards, is a two-room building, containing complete equipment for preparing samples of ores, rocks, fuels and pig iron. The apparatus consists of two gyratory crushers in different sizes, a large pan grinder, chrome steel bucking boards for fine grinding, hand mortars for small samples and a compressed air, impact crusher for shot samples of iron. The machinery is motor-driven. The ores are dried, preparatory to grinding, in open pans on steam-heated stands. The metal samples are drilled in a separate room, convenient to the mill and laboratory, in which there are two presses.

Returning to the laboratory proper, it will be noted that for the ore and metal analysis there are two large rooms, each of which has its own equipment, with separate balance rooms. The furnace and still rooms are common to both laboratories, serving also as passage ways. The furnace is gas-fired, has two muffles, and is adapted to ignitions, annealing, etc. The still is of the Jewell type. The gas analysis is performed in a separate room, equipped with a complete Orsat apparatus with all the attendant fixtures and appliances for expediting the work. The Barnhart apparatus has recently been installed on trial.

The working rooms are provided with a commodious supply of natural gas, running water (two sinks in each room), air blast at 100 pounds pressure and steam suction at 20 inches vacuum. Notwithstanding the fact that strong acid solutions are being evaporated continuously, the atmosphere of the rooms

is remarkably free from fumes, thanks to the efficiency of the hoods. Some who are trying all kinds of devices in their struggle with the fume nuisance might profit by an examination of these hoods. They are placed centrally in the rooms, and have natural draft, the apexes terminating in tall, straight flues. The work is further facilitated by steam-heated, drying ovens, a large, steam-heated sand bath, motor-driven shakers and stirrers and numerous devices of home design. The stock of light chemicals, the laboratory records and all of the standards are kept in a fireproof vault, so that work would not be long suspended in case of fire.

Last but not least of the equipment is the library. In the laboratory office is to be found a respectable and growing number of standard texts, the burden of which is the chemistry of iron and steel manufacture and general analytical chemistry, so that the chemists do not lack for reference matter close at hand. Leading chemical and metallurgical magazines are also carried.

But the more abiding impressions that one will carry away are not of the things one sees, but of the systems and order with which the work is performed, and incidentally, of the lack of some things too commonly seen in chemical laboratories. The apparatus, fixtures and desks are *always* clean and in repair, and superfluous things are rarely to be found. Newspapers and cigarettes are strictly out of order where work is going on. Every employee is expected to be a part of the general scheme so essential to the efficiency of the department. There is a premium put upon good workmanship and studiousness, and the entering chemist is encouraged to prepare himself for the better positions. Chemical students who are fortunate enough to gain admission for their vacations, acquire experience and training which they could never receive at college. The ambitious chemist will aspire to things that can not there be offered, but he will appreciate the advantage of his apprenticeship in the old laboratory at Duquesne.

ROPER CUPELLATION TEMPERATURE.

Rose calls attention to the importance of the temperature of cupellation in gold assaying. Pure lead melts at 326°C. and "uncovers" at the rather low red heat of about 675°C., while litharge freezes at 640°C. A good temperature for the air in the muffle, according to the author, is 700°C., which need not be reduced throughout the operation. While this temperature is too high for feathered crystals of litharge to form on the cupel, yet absorption of the litharge is complete while losses are, nevertheless, low. When antimony, iron, etc., are present in the buttons, the temperature must be much higher or the buttons will freeze; time is saved in all cases by using a temperature higher than 700° (?) at first, but the losses are then greater.

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

HENRY WYSOR, Metallurgical Editor.

PUBLISHED MONTHLY BY

THE CHEMICAL ENGINEER PUBLISHING COMPANY

355 Dearborn Street, Chicago

Entered as Second Class Matter, Aug. 19, 1907, at the Post Office at Chicago, Illinois, March 3, 1879.

Subscription—United States, Cuba and Mexico
Extra postage to Canada 25c a year; to foreign countries 50c a year.
Remittances may be made by check, draft, or money order in favor of
THE CHEMICAL ENGINEER PUBLISHING CO.

All matter connected with subscriptions or advertising should be sent to
THE CHEMICAL ENGINEER PUBLISHING CO., 355 Dearborn street, Chicago.
Anything intended for the Editorial Department should be sent directly to
the Editor, Richard K. Meade, Allentown National Bank Bldg., Allentown, Pa.

NOTES AND COMMENTS.

Prof. Thomas B. Stillman, Professor of Engineering Chemistry at Stevens Institute, has retired under the provision of the Carnegie Foundation for the Promotion of Teaching. Prof. Stillman is known to the technical chemists of the country through his well known book on engineering chemistry. He has been for thirty-one years connected with the department of chemistry of Stevens Institute, and since 1886 has been professor of Engineering Chemistry. He was a pupil of Fresenius, the father of analytical chemistry.

Uniform Nomenclature of Iron and Steel.

At the recent meeting of the International Association for Testing Materials, Professor Henry M. Howe and Professor Albert Sauveur, chairman and secretary respectively, of the committee on "uniform nomenclature of iron and steel," presented their report.

The report first took up the definitions of the microscopical constituents of iron and steel, and stated that these definitions were based on the known and usually indisputable properties of the several constituents, and not on their nature or constitution, which were still in dispute and likely to remain so for some time because of the complexity of their genesis and the imperfection and obscurity of our evidence.

Professor Howe suggested the word "metaral," the analogue of the mineral, as equivalent of the bulky term "microscopical constituent." It was more accurate than "microscopical constituent," because these substances were often far from being microscopical as, for instance, the graphite of pig iron and the primary cementite of ferro-manganese. Moreover, "constituent" seemed vague. Occluded gas and dissolved iron oxide were surely constituents, but hardly "metarals," just as the carbonic acid dissolved in mineral water, though a constituent, was not itself a distinct mineral when so dissolved. Dealing with other appellation, the authors stated that osmondite and troostite-sorbite—stages intermediate between troostite and sorbite—had been described by some writers, but the committee believed that these terms, which at most represented constituents of only hypothetical existence,

were neither known nor used enough to justify giving a place in the list of definitions contained in the report.

In the discussion which followed M. Le Chatelier call attention to the fact that each country, had of course, its own language, and no congress could fix a name to be generally adopted for any product. The report was a useful complement to a technical dictionary. In order to show the difficulty of agreeing upon a name, he stated that what Mr. Stead called "sorbite," Mr. Osmond called "troostite," and Professor Heyn called "osmondite;" in some cases, therefore, it was almost impossible to see clear in these matters owing to the confusion of names. The authors had proposed a new word, "metaral"; but if this new word were adopted, it would have to be applied in each instance with accuracy, and to metallic constituents, and not to all substances generally classified as minerals. Granite was not strictly considered as a mineral, and pearlite could not be called a metaral. The matter should be looked into afresh.

Accident Insurance and The Chemical Industry.

The numerous accidents which have occurred recently in plants devoted to the manufacture of celluloid, in which lives have been lost, and men and women have been maimed for life, have caused some discussion of the question of the liability of the employer and of the need for the insurance of wage earners in such dangerous callings. Probably a vast majority of the chemical lines of manufacture may be classed as hazardous work. The need, therefore, for the manufacturer of chemicals and compounds in which chemicals are used, to provide for their employe in case of accident, is evident. While, in many cases the employer may be able to shift the blame for the accident upon the employe, it is nevertheless incumbent upon him to devise ways and means whereby the injured employe and his family may not become a burden upon the community. So long as manufacturing depends on labor and reaps the benefit of labor, just so long must the manufacturer recognize as his own interest anything which goes to promote the welfare of the wage earner.

Nearly every manufacturing industry in this country has been brought up to its present success not alone by the push and energy of the manufacturer himself, but also by the skill which the wage earner has acquired. This very skill, which is of such value to the manufacturer, in many instances makes the employe careless and callous to danger. It is usually the skilled employee and not the novice who is injured, and very often injury is the direct result of skill. A slip of even the skilled hand may result in permanent injury or death. Employers have long enough alleged carelessness, ignorance and incompetency on the part of the men as an excuse for the cause of accidents, and it is time that they rid themselves of such erroneous impressions and accept the fact that regardless of all these three causes, accidents are of fre-

quent occurrence. It is the old story of "the pitcher that goes to the well."

Employees, on their part, have long enough declared that the employer was callous to their welfare, and that the dollars which he puts in his pocket are of more interest to him than the lives and welfare of those whom he employs. Such charges and counter charges do not solve the question. The general problem in which both the employer and the employee are interested is the maintenance of the man who is injured and his family, or of the latter where the man is killed.

A system of pensions should be compulsory. It is probable that only in very large works will it ever be adopted voluntarily. Therefore, probably the best solution would be compulsory insurance, not paid by the man himself but by his employer. It is certain that in the vast majority of cases the amount of money expended for legal services would be sufficient to, in a measure at least, make up to the injured party for the harm of the accident. According to the Bureau of Commerce and Labor, if two thousand dollars were paid for each fatal accident and one-half wages for two months idleness caused by accident, the total amount of such compensation would only amount to 0.015 per cent of the value of the products which are produced by the manufacturer. In other words, at a cost of less than .02 per cent the claims of the killed and injured could be covered.

Surely the labor of the man is as essential to the success of the manufacturing enterprise as is the machine which he operates, and he should at least be put on an equality with the machine, and the cost of a broken arm or a fractured leg could legitimately be classed as one of the operating expenses and properly itemized as a charge against the industry, to be listed as are the other losses of the business. In many industries, the occurrence of accidents are so regular that those investing their capital in them would know just what risk they took and to what their loss along an insurance plan would amount. Small plants could provide adequate insurance through some of the existing companies which make a business of accident insurance. While the proposition has been constantly made that the laborer should insure himself, the unfairness of this may be realized when we consider the freedom of the employer from all legal expense incidental to accidents to his employees, and hence simple justice requires that the charge of insurance should be borne by the company and no part of it should be taken from the wages of the working men.

The problem is one which should be considered long and carefully by the chemical manufacturer. In many instances, the retirement of the working man is not caused by accident or even carelessness, but by the continued inhalation of noxious fumes and poisonous dust. In the manufacture of many chemicals, the laborer's life is unquestionably shortened. In such industries, where no means of safeguarding the health

of the employees have been found, a definite portion of the profits should be set aside for the maintenance of a pension fund.

It is hardly enough for the manufacturer to pass the question over by saying that the employee is willing to run the risk, and that if he does not do it, he can obtain other workmen who will, or even that the compensation paid is such that a portion of it may be laid aside. In many instances the wage earner does not realize the danger to his health that the work will entail. The chemical manufacturer seldom employs labor of a high enough grade of intelligence to appreciate the danger which is run in handling explosive, inflammable and poisonous chemicals, particularly where accidents are of frequent occurrence. Almost never is the laborer intelligent enough to appreciate the danger to lung and other body tissues which may result from continued exposures to gases and dust. In other words, the manufacturer, by reason of his intelligence, the fact that he reaps equally with his wage earners the benefits of their toil, and his obligation to humanity, must do the thinking for the men whom he employs; just as in most cases he must design the machinery which they use and the process which they carry out

BOOK REVIEWS.

WEST VIRGINIA GEOLOGICAL SURVEY. VOL. IV, IRON ORES, SALT AND SANDSTONE. By G. P. Grimsley, Assistant Geologist. 8 vo. Cloth. Illustrated. 603 pages. Price \$2.00. West Virginia Geological Survey, Morgantown, W. Va.

This volume gives descriptions and analyses of all the principal Iron Ore deposits of the State, together with a history of the old charcoal furnace industry. The main building stones of the State are also described and elaborate tests of their strength and crushing limit made by the War Department at the Watertown Arsenal, and also by the U. S. G. Survey Testing Laboratory at St. Louis, together with chemical analyses, petrographic determinations, etc. The Glass Sands are also described, and chemical analyses published. The report is illustrated with 24 page plates, and 16 figures and maps and in the text, showing location of iron ores, geological structures, illustrations of Blast Furnaces, etc.

INTRODUCTION TO THE CHEMISTRY AND PHYSICS OF BUILDING MATERIAL. By Alan E. Munby. 8 vo. Cloth. Illustrated. 345 pages. Price \$2.00. D. Van Nostrand Co., New York, 1909.

This book is intended to "enable anyone with no knowledge of natural science whatever to appreciate something of the chemical and physical principles which underlie the use of building materials."

The first part of the book deals with elementary science and explains the principles of chemistry, phys-

ics and geology which influence the production, use and decay of materials. In the second part these principles are applied to the study of stones, brick clays, limes and cements, the metals, timber and paints. The chapters in the first part of the book are upon natural laws and scientific investigations, on measurement and the properties of matter, the air and combustion, heat: its nature and measurement, heat and its effects on materials, chemical signs and calculations, water and its impurities, sulphur and the nature of acids and bases, coal and its products, and outlines of geology. The second part of the book, which comprises more than two-thirds of it, takes up the various building materials in order. The chapters are on the constituents of stones, clays, and cementing materials, classification of stones, the examination and testing of stones, brick and other clays, kiln reactions and the properties of burnt clays, plasters and limes, cements, theories upon the setting of plasters and hydraulic materials, artificial stone, oxychloride cement, asphalt, the metals—their general properties and occurrence, iron and steel, other metals and alloys, tests upon and strength of the metals, timber, paints: general characters. Oils, thinners, and varnishes, and paints—their solid ingredients—bases, pigments and driers.

In general these chapters deal only with the chemistry of the material. No methods of analysis are given and in most instances the descriptions of the tests are merely superficial. The book contains a large amount of material and some of the chapters are quite satisfying, while others are entirely disappointing. At the same time, the book is one which may be generally recommended to the profession.

CHEMICAL SOCIETIES.

The opening meeting of the New York Section of the Society of Chemical Industry was held at the Chemists' Club, New York City, on Friday evening, October 22nd. The program consisted of an address by the chairman, Maximilian Tock, on "The Influence of Chemistry on Commerce." This was followed by an interesting paper by Mr. Frederick Falding, on "A New Form of Lead Sulphuric Acid Chamber." The meeting, as usual, was preceded by an informal dinner at the Cafe of the Hotel Savoy.

FALL MEETING AMERICAN ELECTROCHEMICAL SOCIETY.

The sixteenth meeting of the American Electrochemical Chemical Society was held in New York City, October 28, 29 and 30. The sessions were held at the Chemists' Club, and at Columbia University. Friday was devoted entirely to excursions to the industries of Bayonne, N. J., and at night to a subscription dinner at the Hotel Cumberland. On Saturday evening, the Society was the guest of the Chemists' Club, at a smoker in the Assembly Room of the Club. At this

latter event the famous "section Q" of the Club gave one of its rousing entertainments.

The papers presented at the various sessions were as follows: The Titanium Arc, W. S. Weedon; The Element Boron, E. Weintraub; A New Electrolytic Method for the Preparation of Explosive Antimony, R. C. Palmer; Advances in Electrochemical Analysis, Dr. Edgar F. Smith; The Preparation of Silundum, S. A. Tucker, H. F. Kudlich and E. M. Heumann; The Laws of Electrode Losses in Electric Furnaces, Carl Hering; Furnace Electrode Losses, C. A. Hansen; Electrode Losses and Furnace Efficiency, E. F. Roeber; A New Method of Measuring Mean Thermal and Electrical Conductivities of Electrodes, Carl Hering; The Practical Conductance of Electrolytes, Jos. W. Richards and W. S. Landis; Evolution and Present Status of the Dry Cell, J. W. Brown; Dry Cell Tests, F. H. Loveridge; Some Characteristics of Dry Cells, C. F. Burgess and Carl Hambuechen; The Manufacture of Air-Salt-peter by the Process of the Badische Anilin and Soda Fabrik, Dr. C. Schonherr; Power for Electrolytic Copper Refining at the Buffalo Smelting Works, W. L. Spalding; A Process for Simultaneously Cleaning, Annealing and Zincing Wire by Electrochemical Cementation, Alfred Sand; Alloys of Copper with Electrolytic Iron, C. F. Burgess and James Aston; Notes on Zinc, Copper and Brass Dusts, Alfred Sang; A New Theory for Corrosion, Maximilian Toch.

PROGRAM OF THE ANNUAL MEETING OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The second annual meeting of the American Institute of Chemical Engineers will be held December 8, 9, 10 and 11, at Philadelphia, Pa. The headquarters will be at the Hotel Walton.

An extensive and very interesting program has been prepared, and a cordial invitation is extended to all chemists and engineers interested in Chemical Engineering to attend this meeting.

The program arranged is as follows:

WEDNESDAY, DEC. 8, 1909.

10:00 a. m.

Meeting at Hotel Walton.

Address of welcome, Mayor John E. Reyburn.

Business session.

Reports of officers and council.

Reports of committees.

11:30 a. m.

Reading of papers.

1. "Natural Draft Gas Producers and Gas Furnaces," Ernest Schmatolla. Discussion by O. K. Zwingenberger and G. E. Barton.

2. "The Commercial Extraction of Greases and Oils," Wm. M. Booth. Discussion by Frederick Dannerth, Louis Olney and Samuel P. Sadtler.

12:30 p. m.

Luncheon at Hotel Walton. (\$0.75 table d'hôte.)

- 1:30 p. m.
Visit to Chemical, Engineering and Physical Laboratories of the University of Pennsylvania.
Visit to Commercial Museum of Philadelphia. Dr. W. P. Wilson.
- 1:00 p. m.
Luncheon at works of Harrison Bros. & Co., Gray's Ferry Road. Excursion through works. (Admission by card only.)
- 7:30 p. m.
Address of retiring president.
Address, "The Chemical Industries of America," Prof. Chas. E. Munroe.

THURSDAY, DEC. 9, 1909.

- 9:30 a. m.
Members of institute and their guests will assemble at Race Street wharf on the Delaware and be conveyed by the city boat, "S. H. Ashbridge," to the Torresdale Filtration Plant. Returning stop at Tacony to visit the Wool Degreasing Plant of Erbin, Harding & Co.
- 12:30 p. m.
Luncheon at the works of the Welsbach Light Co. as the guests of the company.
- 1:30 p. m.
Excursion through the works of the Welsbach Light Co.
- 3:00 p. m.
Return by boat to Kaighn's Point, Camden, and excursion through By-Product Coke Oven Plant of the Camden Coke Co.
- 5:00 p. m.
Return to Chestnut Street wharf, Philadelphia.
- 7:00 p. m.
Subscription dinner at the Hotel Walton, \$3.00.

FRIDAY, DEC. 10, 1909.

- 9:30 p. m.
Installation of officers and business meeting.
- 10:30 a. m.
Reading of papers.
3. "Multiple Effect Distillation," F. J. Wood, Mechanical Engineer of Mark & Ravelle's Glycerine Refinery.
4. "The Advantages of the Multiple Effect Distillation of Glycerine and Other Products," A. C. Langmuir. Discussion by S. S. Sadtler and Chas. L. Reese.
5. "Reclaiming of Waste India Rubber," S. P. Sharples. Discussion by Wm. M. Grosvenor.
- 12:00 m.
Luncheon at Hotel Walton.
- 1:00 p. m.
Leave Broad Street Station for Trenton, N. J.
- 2:00 p. m.
Excursions: Trenton Potteries, The Hamilton Rubber Co., Linoleum Works.

- 7:30 p. m.
Reading of papers.
6. "Materials for Textile Chemical Machines," Frederick Dannenrth. Discussion by Louis A. Olney and J. M. Mathews.
7. "The Manufacture of Carbon Bisulphide," Edward R. Taylor.
8. "Chemical Composition of Illinois Coal," A. Bement.
9. "Heat Efficiency of Smokeless Combustion and Heat Absorbing Capacity of Boilers," A. Bement.
- 9:00 p. m.
Final business meeting.
- SATURDAY, DEC. 11, 1909.
Visit to Cement Plant at Allentown, Pa.

INDUSTRIAL PLANT NEWS.

Chemicals.—The General Chemical Company, 25 Broadway, New York, N. Y., has let the contracts for the construction of the buildings for its plant at Newell, Pa., to the Nicola Building Company, Farmers' Bank building, Pittsburg, Pa. More than \$1,000,000 will be spent on the buildings, which will be seven in number. It will be so arranged that the raw product will be started in at one end of the plant and the finished product packed for shipment at the other. The plant will cover over thirty acres.

Chemicals.—The Ohio Valley Chemical Company and the Central Chemical Company of Cincinnati were incorporated in Ohio in October, with a nominal capital of \$12,000 each. These concerns are to take over the properties of the Globe Chemical Company and the Ohio River Chemical Company to develop and extend them. Work upon the additions has been begun at the present Cincinnati plants, and they will be extended and improved so as to admit of a much larger output and wider field of trade.

Enameled Iron.—The Wheeling Enameled Iron Company, Elm Grove, W. Va., has awarded the contract to the John Eichleay, Jr., Company, Pittsburg, Pa., for remodeling their foundry building at Elm Grove, W. Va. Schreiber, Johnson & Risacher of Pittsburg, Pa., have been awarded the contract for installing a sand handling plant. A gas engine of 150 horse power will furnish additional power for the plant.

Ferro-Silicon.—The Bessie Ferro-Silicon Company, Columbus, Ohio, is increasing its capacity by building an additional stack to the plant at New Straitsville, Ohio. The stack will be 75x17 feet and of the most modern design. Three Amsler hot blast stoves, 75x18 feet, will be built in connection with the furnace. The company is at present operating a stack 60x14 feet with an annual capacity of 18,000 tons of ferro-silicon.

Fertilizers.—The Southern Fertilizer & Chemical Company has closed a contract for a modern fertilizer plant at Savannah, Ga., on the Hutchinson's Island terminal of the Seaboard Air Line railway. The Pratt Engineering and Machine Company of Atlanta, Ga., has the contract for the construction of the plant. The cost of the latter is to be \$50,000 and will have a capacity of from 30,000 to 35,000 tons of fertilizer each season. It is anticipated that it will be ready for operation by Feb. 1st, 1910.

Gas.—The municipal authorities at Wheeling, W. Va., are considering the rebuilding of their gas plant. It is estimated that the improvements will cost \$110,000.

Graphite.—The International Acheson Graphite Company of Niagara Falls, Ont., have awarded to W. S. Homan of Niag-

ara Falls, Ont., a contract for an addition to their plant of 50x105 feet. The building will contain a grinding plant in which the lubricating, electrotypes and other grades of powdered graphite will be made ready for the market. It will also contain a stock room for packing goods, such as graphite greases, powders, etc.

Lard.—Armour & Co., 169 Duane street, New York, announce that they have secured a tract of land at Carteret, N. J., on which they will erect a plant for the manufacture of lard. Construction will probably be begun Jan. 1st.

Paper.—The Itasca Paper Company will double the size of its present mill at Grand Rapids, Minn. The contemplated changes will cost between \$300,000 and \$400,000.

Soap.—Wm. Kellar is interested in a company which will build a soap factory upon a piece of property which he owns at New South Memphis, Tenn. The factory consists of a four-story building, equipped with the most modern machinery. Construction will be begun shortly.

Steel.—The Republic Iron & Steel Company, Pittsburg, Pa., has prepared plans for a plant in Youngstown, Ohio, which will cost, when erected, \$2,000,000. It is reported also that the Republic Iron & Steel Company will let contracts soon for two additional blast furnaces and six open hearth furnaces, at Hazelton, Pa., and Lansingville, and that six additional open hearth furnaces will be erected after the first six are in operation.

Steel.—An issue of \$7,500,000 of notes was authorized by the stockholders of the Bethlehem Steel Company at a meeting in Newark, N. J., on Nov. 5th. About \$5,000,000 of this will be used to double the capacity of the rolling mills at Bethlehem and for the erection of necessary blast furnaces, etc. The company will build two modern blast furnaces in addition to the one now under construction. The plant will consist of ten 50-ton open hearth furnaces, duplicating the existing Saucen plant, or two 20-ton Bessemer converters. If the latter are decided upon, it is the expectation that the duplex process will double the output of the existing open hearth furnace.

Storage Battery.—The Westinghouse Storage Battery Company, which was incorporated in July, with a capital of \$1,750,000, has taken over the General Storage Battery Company, the works of which are at Bonton, N. J., and the storage battery department of the Westinghouse Machine Company, which will be transferred to the latter point.

Sugar.—F. C. Durant of New York, N. Y.; M. H. Day of Montreal, Que., and others, will erect a sugar refinery at St. John, N. B., to cost \$2,000,000 and employ at least 500 men.

Tin Plate.—The McKeesport Tin Plate Company have awarded a contract for the addition in course of construction at the company's plant at McKeesport. Geo. J. Hagan, Pittsburg, Pa., will install for them ten sheet and ten pair furnaces, seven double and five gas producers. The Allis-Chalmers Company of Milwaukee will supply the electrical machinery.

Tin Plate.—The recently organized Union Sheet & Tin Plate Company, Farmers' Bank building, Pittsburg, Pa., recently purchased the plant of the Marietta Sheet & Tin Plate Company, at Marietta, O., announce the closing of the deal for the purchase of the plant and business of the Hazelton Sheet Steel Company, at Hazelton, Pa. The latter plant is equipped with rolling mills, galvanizing works and steel roofing factory. The company announces that it will not make tin andterne plates before January 1st, but is now a seller of black and galvanized sheets and sheet metal products.

Zinc.—The Clarksburg Zinc Company's plant at Clarksburg, Pa., has been purchased by E. G. Pearlman of Philadelphia for \$42,000.

RECENT PATENTS.

The following patents relating to industrial engineering are reported by C. L. Parker, solicitor of chemical patents, McGill building, 908 G street, N. W., Washington, D. C.:

931,522. *Method of Making Litharge.* James E. Sullivan, Camden, N. J. Aug. 17, 1909.

The method consists in subjecting monoxide of lead to a temperature ranging between 900° and 1,200° Fah. during a period of three hours, more or less, and then mechanically reducing the derived litharge to a uniformly powdered commercial condition.

931,523. *Solder for Aluminum.* Zoltan Tamassy, Cleveland, Ohio. Aug. 17, 1909.

The composition consists of antimony, zinc spelter, pure tin and salicylic acid.

931,584. *Process of Producing Milk-Sugar.* Andrew A. Dnuham, Bainbridge, N. Y. Aug. 17, 1909.

The process consists in producing milk sugar by boiling the whey to precipitate the albumen, filtering the whey to remove such precipitated albumen, treating the whey with acid to precipitate the remaining albumen, clarifying the whey by filtering the same through a clarifying material, and then evaporating the clarified whey to crystallization.

931,608. *Process of Recovering Resinous Matter.* William J. Hough, Toledo, Ohio. Aug. 17, 1909.

The process consists in treating vegetable fibrous material containing resin with a hot pulping solution and then separating the cellulose, resinous salts and ligneous matter.

931,634. *Colored Cellulose Articles.* Oscar Muller, Cologne, Germany. Aug. 17, 1909.

This article is produced by dissolving a cellulose mass containing non-fibrous cotton seed shell cellulose in which the natural dye-stuff of the shell is retained and precipitating said cellulose in the desired form with said dye-stuff present, whereby an article colored by the natural dye-stuff of the shell is obtained.

931,805. *Elcoresin of Vanilla.* Edward J. Sheehan, New York, N. Y. Aug. 24, 1909.

The product is an oleo-resinous extract from vanilla bean, containing, in addition to 10 per cent of vanillin, approximately 72 per cent of combined acid and neutral resins, of gummy consistency, deep brownish-amber in color, and which on being treated with a 65 per cent alcoholic solution yields but 11 per cent of its resinous constituent.

931,846. *Process of Making Fertilizer.* James H. Connor, Nashville, Tenn. Aug. 24, 1909.

This is a method of producing a phosphate by reducing five parts of phosphate rock or calcium phosphate to the form of a powder, adding one part of caustic soda and two parts of quick lime and mix in water until the same assumes the consistency of thick mud, and finally subjecting this mixture to a high degree of heat until the phosphoric acid becomes available.

931,868. *Process of Purifying Gases Containing Sulphur Dioxide.* Herman Hegeler, Danville, and Nicholas L. Heinz, La Salle, Ill. Aug. 24, 1909.

The process consists in first mixing hot sulphurous gases from a burner with sufficient cooled burner gases of about equal sulphur dioxide content to produce the temperature desired; second, passing such mixture of gases upward through a filled purifying tower and subjecting the same to the resistance of said tower and to the action of finely divided streams of water tricking down through such tower.

932,204. *Manufacture of Soluble Alkali Silicates.* Rudolph E. Weissmuller, Runcorn, England. Aug. 24, 1909.

This product is a scaly anhydrous alkali silicate readily soluble in water at atmospheric pressure.

932,280. *Fixed-Color Cementitious Compound and Process of Producing the same.*

This is a cementitious compound having a fixed color, consisting of a cementitious ingredient, a colored stearate of iron, and an additional amount of iron pigment.

932,374. *Method of Making Portland Cement.* Joseph H. Carrero, Allentown, Pa. Aug. 24, 1909.

The process consists in mixing with lime and a silicious material, carbonate of zinc, burning the same and then pulverizing the clinker produced thereby.

932,459. *Method of Reducing and Melting Oxides and the Like.* Otto Frick, Sheffield, England. Aug. 31, 1909.

This is a method of reducing and melting oxides by successively introducing the solid material to be treated between electrodes in such a manner as to continually form a continuous conductor of high resistant material between the said electrodes, reducing the said material by causing an alternating electric current to flow through the said continuous high-resistant conductor between the electrodes, allowing the reduced material to sink into an annular crucible, and melting the reduced material by electric current induced in the melted material within the crucible.

932,470. *Process for Recovery of Ingredients of Oily Inks.* Matthew S. Hopkins and Charles R. Barnett, Baltimore, Md. Aug. 31, 1909.

The process consists in mixing acetone with oily ink to reduce the viscosity of the oil and mechanically divorce the pigment therefrom, mechanically filtering the liquor to recover the pigment, and then treating the resulting liquid to recover the oil and acetone respectively.

932,527. *Process of Treating Vegetable Albumen and Animal Casein and the Product Therefrom.* Ferdinand G. Wiechmann, New York, N. Y. Aug. 31, 1909.

The process of treating the products to render them lighter than water by subjecting them to the action of hydrogen peroxid.

932,622. *Composition of Matter.* Tillman D. Lynch, Wilkinsburg, and John J. Crane, Swissvale, Pa. Aug. 31, 1909. The composition comprises ingredients in substantially the following proportions: Rosin, 29 parts by weight; brick dust, 40 parts; china clay, 18 parts; and asphalt having a high melting point, 13 parts.

932,643. *Process of Leaching Copper Ores.* George C. Schneider, Freiberg, Germany. Aug. 31, 1909.

The process for leaching copper ores consists in treating the said ores after a previous roasting with a solution of caustic alkali in presence of organic substances that are capable of dissolving cupric hydroxide.

932,689. *Process of Oxidizing Ores.* Byron E. Eldred, Bronxville, N. Y. Aug. 31, 1909.

The process consists in oxidizing ores with draft currents of air diluted with controlled proportions of products of complete combustion and a modicum of combustible gas.

932,758. *Method of Recovering Ammonia from Coal-Gas.* Francis J. Collin, Dortmund, Germany. Aug. 31, 1909.

The method consists in recovering ammonia from coal-gases, by saturating the hot gases with steam immediately upon entering the gas-collecting main, and then cooling them to recover the contained ammonia.

932,795. *Process of Separating Suspended Matter from Liquids Containing Mineral Value.* Prosper J. A. Maignen, Philadelphia, Pa. Aug. 31, 1909.

The process consists in separating suspended matter from a liquid containing mineral value by adding to said liquid sodium carbonate and aluminum sulphate in a liquid state, in such proportions as not to substantially affect the degree of alkalinity of said liquid.

932,839. *Substitute for Tin Oxide Used for Enameling Metal Ware.* Rudolph Weimer, Sheboygan, Wis. April 31, 1909.

This is a composition consisting of seventy parts antimony oxide, twenty-eight parts caustic soda, twenty-two parts Chile saltpeter, ten parts kaolin and ten parts barytes.

932,855. *Manufacture of Lubricating Compounds.* John E. Gill, Franklin, Pa. Aug. 31, 1909.

This is a process comprising a compound of lead with animal oil, subjecting the combination to heat until brought to a homogeneous fluid condition, adding a quantity of animal product which is solid or semisolid at ordinary temperature thereto, and cooling the resulting compound to a homogeneous, relatively solid mass.

932,898. *Art or Process of Producing Ozone.* James F. Place, Glen Ridge, N. J. Aug. 31, 1909.

The process consists in evaporating liquid oxygen by heat drawn from a column of air in a pipe submerged therein, and subjecting the cold vapor and oxygen gases from said evaporating liquid to an electric current in an ozonizer.

932,917. *Process for Manufacturing Cement.* Maximilian Trembour, Birmingham, Ala. Aug. 31, 1909.

The process consists in manufacturing cement from furnace slag by adding to and intimately mingling with the molten slag a solution of sulphuric acid.

932,964. *Copperizing Iron.* William G. Clark, Geelong, Victoria, Australia. Aug. 31, 1909.

The method consists in heating and immersing the iron in a bath of molten copper in the presence of a flux composed essentially of noracid acid, tartar and sal-ammoniac.

933,060. *Explosive.* Charles Clement and Jean Langhard, Vallorbe, Switzerland. September 7, 1909.

The explosive consists of a mixture of suet, benzene and potassium chlorate.

933,107. *Manufacture of Acetone.* Albert L. A. Pages and Rene P. T. Dychemin, Paris, France, September 7, 1909.

The process consists in passing continuously vapors of distilled pyroligneous acid over a heated acetate capable of forming acetone on heating, said acetate being maintained at a temperature lower than that of incipient red, leading off the acetate thus formed and condensing the same.

933,133. *Process of Treating Zinc Ores.* Frederick T. Snyder, Oak Park, Ill. September 7, 1909.

This is a process of treating zinc-lead ores, in which the ore is smelted with carbon upon a slag bath, which is floated upon a molten lead electrode in an electric furnace from which air is excluded, electric current being passed through the slag between said molten electrode and a second electrode in contact with the slag, and the temperature thereby maintained at a point between the volatilization temperatures of lead and zinc, whereby the ores of lead and zinc are reduced and the metals separated, the lead sinking through the slag to add to said electrode, while the zinc is vaporized and separately collected.

933,433. *Solder for Aluminum.* Jacques F. Guggenbuhl, Paris, France, September 7, 1909.

The solder contains the following metals in the approximate portion stated: Zinc, 85 per cent; copper, 10-7 per cent; and aluminum, 43-10 per cent.

933,437. *Art of Transforming Wood.* William A. Hall, New York, N. Y. September 7, 1909.

The process consists in treating the wood at a high temperature with an alkaline solution containing saccharine, which solution is caused to permeate the wood throughout.

933,491. *Ore Separating Process.* Marcus Ruthenburg, Lockport, N. Y. September 7, 1909.

This is a process of separating ore or concentrate particles of different specific gravity, which cannot be wetted in water, which consists in surrounding the same with a liquid hydrocarbon capable of wetting the surfaces of said particles so that they are separated by gravity without flotation in said liquid.

933,596. *Process for the Manufacture of Steel.* Guy J. Stock, Darlington, England. September 7, 1909.

This is an improvement in the production of steel by means of a Bessemer or pneumatic converter arranged in combination with an economizer which consists in melting a charge of metal in said converter by means of fuel forced into said converter through the tuyeres thereof, allowing the hot products of combustion to pass through the economizer, then tilting the air by the economizer during the blowing operation.

933,598. *Article Coating Process.* Jesse M. Talmadge, Brooklyn, N. Y. September 7, 1909.

The process consists in mixing a body of tung oil with a hydrocarbon and applying the compound to the body to be coated, and then heating the same to a minimum temperature of 212 degrees Fahrenheit for a period not to exceed a maximum of thirty minutes, whereby the oil is transformed into an insoluble form which is resistant to water, chemicals, fire, heat and electricity.

933,612. *Metallic Product.* George F. Allen, Toronto, Ontario, Canada. September 7, 1909.

The product consists of an iron or steel body, having a coating comprising an alloy of lead and zinc applied combinedly and directly to the body, and a coating of zinc over the first mentioned coating.

933,638. *Solution for and Method of Extracting Resin from Rubber.* Charles P. Flora, Watertown, Mass. September 7, 1909.

The method consists in subjecting the rubber to alcohol first, then to a mixture of benzol and alcohol and then to the alcohol as a final extraction.

933,645. *Artificial Leather and Process of Making the Same.* Louis V. Guilleaume-Chaput, Paris, France. September 7, 1909.

The process consists in mixing balata gum and dextrine with glycerine and gelatine, supplying a suitable proportion of fibre to the mixture, kneading and molding the mixture to form sheets, passing the sheets thus molded through a press, and finally passing the sheets through a bath of formic aldehyde.

933,717. *Process of Treating Ores.* Alfred A. Lockwood and Marcus R. A. Samuel, London, England. September 7, 1909.

The process consists in mixing an ore with a magnetic substance and an oily liquid adapted to cause the magnetic substance to adhere to some constituent part of the ore in preference to the others, and then magnetically separating the mixture.

933,725. *Sherardizing Apparatus.* Alfred F. Schroeder, Cleveland, Ohio. September 7, 1909.

Sherardizing is a process of galvanizing by heating the articles to be coated to a temperature of about 500 to 600 degrees in contact with zinc dust for about hours, the articles and surrounding dust being agitated during the process. The patentee's apparatus is designed for carrying out this process more rapidly, conveniently and economically than has been heretofore possible.

933,751. *Method for Making Sound Metal Ingots and Other Castings.* Robert A. Hadfield, Sheffield, England. September 14, 1909.

This process consists in casting the metal, placing a layer of slag on top thereof, adding solid fuel above the slag and directing a downward blast of air against such field to promote its combustion and keep the metal in a fluid condition.

933,875. *Composition of Matter.* George E. Boggs, Philadelphia, Pa. September 14, 1909.

The composition consists of a powder comprising one part each of magnesium carbonate, potassium sulphate, sodium chloride and a starch.

934,020. *Explosive.* Otto F. Von Schroetter, Kruppamuhle, Germany. September 14, 1909.

The explosive consists of hexanitrodiphenylamin and a nitrihydrocarbon of a low melting point.

934,036. *Composition of Matter for Manufacturing Hydrogen Gas.* George F. Brindley, San Francisco, Cal. September 14, 1909.

The composition of matter comprises a mixture of powdered aluminum and silicon with caustic soda.

934,056. *Process of Making Cement Clinker and Apparatus Therefor.* Carleton Ellis, White Plains, N. Y. September 14, 1909.

This is a process of producing cement clinker by calcining the raw cement forming materials in a rotary kiln to practically complete expulsion of CO₂, grinding and mixing the same, and returning to a rotary kiln and reheating to form clinker, said calcining and reheating being performed by a common source of heat.

934,257. *Process for the Purification of Rosin.* Homer T. Yaryan, Toledo, Ohio. September 14, 1909.

The process consists in purifying rosin in solution with a hydro-carbon by mixing and agitating the solution with cold water, for the purpose of precipitating the impurities; then by gravity causing a separation into strata of the water, the precipitate thus obtained and the solution, and then separating the two stratum from said strata.

934,278. *Method of Manufacturing Nickel and Nickel Copper Alloys.* David H. Browne, Copper Clipp, Ontario, Canada. September 14, 1909.

The method consists in subjecting sulphur compounds of nickel or nickel copper alloys to fusion with electric heat in the presence of lime, causing thereby the combination of sulphur with lime as sulphide of calcium, the evolution of sulphur dioxide and the production of nickel or nickel alloy.

934,379. *Process of Producing Calcium Silicide.* Thomas L. Willson and Maximilian H. Haff, Ottawa, Ontario. September 14, 1909.

This is a process of producing a compound containing an alkaline earth metal and silicon by heating a metallic carbide of an alkaline earth with silica in the electric arc.

934,467. *Manufacture of Chlorine Compound of Lime.* Hermann Schultze, Gresheim, Germany. September 21, 1909.

The process consists in manufacturing compounds of calcium hypochlorite from milk of lime by chlorinating the latter beyond the specific gravity of 1.15, adding as much lime as is necessary to precipitate the said compounds, and introducing chlorine.

934,637. *Antifriction Alloy.* Enrique A. Toucheda, Albany, N. Y. September 21, 1909.

This is a bearing composed of an alloy containing a relatively large proportion of cadmium and a relatively small proportion of magnesium.

934,704. *Process of Depositing Metals.* Carl H. Zieme, New Castle, Pa. September 21, 1909.

The process consists in laying on the surface to be coated a coherent sheet of fabric containing carbonizing material and loaded with metal to be deposited in partially oxidized form, and then subjecting to heat.

934,710. *Manufacturing of Artificial Stone.* Anton-Brany. Alpha, N. J. September 21, 1909.

The process consists in employing Portland cement, equal parts of half saturated salt water and saturated lime water, stirring the cement, adding the salt and lime water, adding with the stirring a desired coloring matter, molding the mass and allowing the molded mass to crystallize.

934,783. *Mashing Process.* Conrad Zimmer, Barcelona, Spain. September 21, 1909.

The process consists in grinding the malt, separating the husks from the meal, grinding the husks with water, mash-

ing in a fore-mashing tub at a temperature not exceeding 75 degrees centigrade, mashing the meal in a separate mash tub, and drawing the liquid from the tubs into a common vat.

934,844. *Disinfectant*. Hans Schneider, Wilmersdorf, near Berlin, Germany. September 21, 1909.

The disinfectant consists of anhydrous oxalic acid combined with a solution of formaldehyde in such quantities that a solid product is formed.

934,864. *Process of Recovering Nickel Steel Scrap*. Ralph H. Watson, Munhall, Pa. September 21, 1909.

The method consists in melting nickel steel scrap in an open hearth furnace in the presence of sufficient carbonaceous material to liquefy the bath, and then working down the charge and thereby producing nickel steel of substantially the same nickel content as the scrap which is employed.

934,990. *Explosive Compound*. Frank H. Briggs. Painsville, Ohio. September 28, 1909.

The explosive consists of an intimate mixture of chlorate of potash, mirbane oil and pulverized slate.

935,001. *Process of Making Alkali Hydrosulphites*. Bernard Deutecom, Leverkusen, near Cologne, Germany. September 28, 1909.

The process consists in dissolving suitable salts in ammonia, treating this solution with an alkali salt of an acid which forms salts of zinc soluble in ammonia water and isolating the alkali hydrosulphites which are thus caused to crystallize out.

935,234. *Process for Reducing the Amount of Carbon in Cast Iron or Articles Cast from Iron*. Walter Rubel, Vienna, Austria-Hungary. September 28, 1909.

The process consists in treating the cast iron at a temperature from 1,100 to 1,150 degrees C. with molten sodium hydroxide, whereby the hydroxide acts by diffusion on the carbon.

935,250. *Electrolytic Winning of Zinc from Solutions of Zinc Sulphate*. Victor Engelhardt and Max Huth, Charlottenburg, Germany. September 28, 1909.

This is a process of obtaining zinc electrolytically, which consists in subjecting zinc sulphate solution to the action of the electric current passing from an anode of compact lead peroxide free from constituents or parts attackable by the electrolyte to a cathode.

935,292. *Treatment of Materials Containing Silk*. Theodore Boettger, Hackensack, and Frederick Von Eyser, Rochelle Park, N. J. September 28, 1909.

The process consists in subjecting silk to the action of a weakly alkaline solution of turkey red oil in a relatively large quantity of hot water.

935,344. *Process of Making Water Gas*. Charles E. White, Philadelphia, Pa. September 28, 1909.

The process consists in confining a mass of refractory material, heating portions of said mass to different temperatures by the application of different current densities thereto, and passing water vapor or steam through the whole mass and hydrocarbon through a portion of the mass while being electrically heated.

935,358. *Method of Treating Steel Plates*. Cleland Davis, U. S. Navy. September 28, 1909.

The process consists in impregnating the face of a steel plate with foreign matter, by applying said matter to the face of said plate, and thereafter melting the face of the plate and the matter by means of an electric arc, the face of the plate under treatment being in the meantime screened from air.

935,414. *Rubber*. David Sandmann, Berlin, Germany. September 28, 1909.

This is a hard rubber produced by coagulating the sap by a fluorine containing substance, said coagulated product being pressed and vulcanized under heat with a mixture of sulphur

and litharge, the product being elastic, inodorous and containing no appreciable quantity of sulphide of lead.

935,418. *Method of Producing Magnesium Carbonate*. George Sisson, Newcastle-upon-Tyne, England. September 28, 1909.

The process consists in first treating magnesium hydrate with an excess of carbon dioxide until magnesium bicarbonate is formed and dissolved, then adding further magnesium hydrate to the solution of bicarbonate to cause the bicarbonate to give up one-half of the carbon dioxide contained therein and thereby producing a precipitate of magnesium carbonate.

935,572. *Composition for Binding, Surfacing and Resurfacing Purposes in Street and Road Building*. Joseph H. Amics, Philadelphia, Pa. September 28, 1909.

This is a method of making a composition to be used in street and road building and like uses as a binder and for surfacing and resurfacing purposes, which consists in coating mineral matter with crude naphtha, gasoline or alcohol, with or without mixing them with other suitable light oils, then pouring thereon and mixing therewith hot asphalt cement and the like, then separating the particles of the mass by agitating the same until cold in order to secure a granular and friable composition.

935,617. *Process for Manufacturing Cement*. Maximilian Trembour, Harzburg, Germany. September 28, 1909.

The process consists in manufacturing cement from furnace slag by breaking up the molten slag into small particles and then adding thereto, while the slag is in a molten condition and separated into small particles, foreign matter which will cause an envelope to be deposited about the particles of slag.

933,139. *Antifriction Alloy*. Enrique A. Touceda, Albany, N. Y. September 7, 1909.

The alloy contains lead, cadmium and magnesium.

933,145. *Composition of Material for and Process of Manufacture of Railroad Tires, Posts, and Similar Articles*. Frank Weckerly, St. Davids, Pa.

This is a binding or cementing material compounded of coal-tar, dead oil, hard pith and crushed slag.

933,269. *Manufacture of Agglomerated Bodies from Blast Furnace Dust*. Wilhelm Schumacher, Osnabruck, Germany. September 7, 1909.

The process of agglomerating consists in grinding such dust so as to transform its approximately spherical grains into fragments of irregular shape, moistening the mass and forming it into coherent bodies.

933,270. *Manufacture of Coherent Bodies from Blast Furnace Dust*. Wilhelm Schumacher, Osnabruck, Germany. September 7, 1909.

This is a process of agglomerating blast furnace dust with water and with an agent which by a catalytic influence stimulates the binding action of substances contained in the blast furnace dust, and then forming the bodies into coherent bodies.

933,324. *Process of Metal Coating Small Metal Articles*. Edward S. Mowry, Middletown, Conn. September 7, 1909.

This is a process for coating with metal small metal articles, by placing a mass of said articles, combined with the requisite quantity of coating material and flux, in a receptacle, and applying heat thereto upon the inside of said receptacle.

In the laboratories of the General Chemical Company the determination of minute quantities of arsenic in brimstone is performed in the following manner: The brimstone is oxidized by a mixture of three volumes of carbon tetrachloride to two volumes of pure bromine, followed by nitric acid. A little water is added and the nitric acid and carbon tetrachloride removed by evaporation. Arsenic is then determined in residue by Marsh or Gutzeit method.

The Chemical Engineer

PUBLISHED BY

The Chemical Engineer Publishing Co., 355 Dearborn St., Chicago

Vol. X.

DECEMBER, 1909.

No. 6.

THE ULTIMATE COMPOSITION OF PORTLAND CEMENT AND ITS EFFECT UPON PHYSICAL PROPERTIES.*

BY RICHARD K. MEADE.

Director of the Meade Testing Laboratories and Editor of The Chemical Engineer.

The composition of Portland cement may be considered from two viewpoints, that of the analyst and that of the physical chemist. To ascertain by the methods of the former the *ultimate*⁸ or elementary composition was until recently considered a simple matter. To determine by synthesis and the microscope the *proximate* composition, or the relation which these elementary compounds bear to each other, has so far baffled the skill of some of our best physical chemists, though no doubt we are now much nearer the solution of the problem than formerly.

The present state of the art of cement analysis is by no means as satisfactory as it might be, and expert and careful chemists do not always agree upon even the ultimate composition of cement. After the careful work¹ done by two committees and one of the best chemists of the United States Geological Survey, it would seem as if the conditions for accurate work had been so fully established as to insure agreement among skillful chemists. That this is not so the following incident will show. During the last year the writer, was associated with two prominent American chemists in the examination of some thirty samples of cement. The average results of the three sets of determinations are given below and demonstrate clearly how unsatisfactory is the present state of analytical chemistry.

Chemist	Variation Between			
	A.	B.	C.	Extremes.
Lime	60.75	61.13	61.19	0.46
Silica	22.59	22.28	22.11	0.48
Alumina	6.88	7.56	8.59	1.71

*Paper read at the Seventh International Congress of Applied Chemistry, London, Eng.

¹Richardson, Schaffer and Newberry, J. Soc. Chem. Ind., XXI, 830 and 1216 J. Am. Chem. Soc., XXV, 1180 and XXVI, 995. Meade, Newberry and McCready, Cement and Eng. News, Aug., 1904, Chem. Eng., 1.

Hillebrand, J. Am. Chem. Cos., XXIV, 362. Peckham, J. Soc. Chem. Ind., XXI, 831, and J. Am. Chem. Soc., XXVI, 1636.

Blount, J. Am. Chem. Soc., XXVI, 995.

Gano, Chem. Eng., IX, 7.

Iron oxide	3.40	3.61	2.56	0.84
Magnesia	1.20	.92	1.58	0.38
Sulphur trioxide	1.09	1.20	1.31	0.22
Loss on ignition	2.22	2.47	2.37	0.25

Considering our knowledge of the proximate composition of cement, the situation is even more unsatisfactory.

Le Chatelier² in 1887 published as his thesis for the degree of doctor of science a dissertation upon the "Experimental Study of the Constitution of Hydraulic Mortars," in which he propounded the theory that Portland cement was composed of two essential compounds, tricalcium silicate, $3\text{CaO} \cdot \text{SiO}_2$, and tricalcium aluminate, $3\text{CaO} \cdot \text{Al}_2\text{O}_3$. Spencer, B. and W. B. Newberry,³ ten years later, confirmed the views of Le Chatelier so far as tricalcium silicate was concerned, but advanced the theory that the alumina was present as dicalcium aluminate, $2\text{CaO} \cdot \text{Al}_2\text{O}_3$.

In 1897, Törnebohm,⁴ a Swedish petrographer, identified in cement, by the use of the microscope and polarizer upon thin sections of Portland cement clinker, four distinct constituents, which he called *alit*, *belit*, *felit* and *celit*.

Richardson,⁵ in a paper read before the American Cement Manufacturers' Association, in 1904, stated that *alit* was a solid solution of tricalcium silicate in tricalcium aluminate and that *celit* was a solid solution of dicalcium silicate in dicalcium aluminate.

In June, 1906, Day and Shepherd,⁶ in a paper read at the Ithaca meeting of the American Chemical Society, stated that no such compound as tricalcium silicate exists and that the compound so called by others is merely a mixture of lime and calcium orthosilicate (dicalcium silicate). The reasoning and work upon which these latter investigators base their conclusions appear to be so satisfactory as to completely overthrow the theories of their predecessors—Richardson himself acknowledging the probability that they are right.⁷

²Annales des Mines, 1887, p. 345, also Translation by J. L. Mack, McGraw Publishing Co., New York, 1905.

³J. Soc. Chem. Ind., XI, 1035.

⁴Kongreb des intern. verb. für material prüff, Stockholm, 1897. See also Richardson Papers, Asso. Am. Portland Cement Mfgs., June 15, 1904.

⁵Papers, Association of American Portland Cement Mfgs., June 15, 1904.

⁶Am. Chem. Soc., XXVIII, 1089, also abstract in Chem. Eng., IV, 273.

⁷Papers, American Cement Manufacturers' Association, Sept. 12th, 1906.

Thus we find in the last twenty years three radically different theories, each generally accepted and held, for a time at least, as to the proximate⁸ composition of Portland cement, and we would expect these revolutions of theory to have some influence upon the practical manufacture of Portland cement and the ultimate composition of the commercial product. This is not the case, however, and the effect of theory of composition upon practical cement making has been small. In 1896 the writer analyzed a sample of Saylor's cement and again in 1906 another. It is doubtful if both samples had been drawn, at either time, from cement made a few days apart if they would have agreed more closely. The analyses follow:

	1896.	1906.
Silica	22.60	22.38
Iron Oxide	2.30	2.50
Alumina	6.70	6.80
Lime	62.50	62.40
Magnesia	3.38	3.12
Sulphur Trioxide	1.88	1.44

It must not be supposed from the foregoing, however, that American cements are not better to-day than they were ten years ago, for in fact they are on an average much better, but this progress has been due to improved mechanical appliances rather than to any new ideas of how to make Portland cement, brought about by changes of our theory as to what the product really is. Nearly all investigators who attempted to prepare cement of varying composition called attention to the importance of fine grinding of the raw materials, but most mill chemists who were at all observant had previously noticed the relation between the fineness of the raw materials and "constancy of volume" of the resulting product. Great improvements have been made in recent years in grinding machinery. It is now possible to not only grind the raw materials much finer than formerly, but also to do this much more economically. The introduction of mills of the centrifugal type, such as the Fuller-Lehigh Mill, as well as improvements in the tube mill and methods of transmitting power to the mills have aided materially in cheapening the grinding of the raw materials to the point where the introduction of these latter into the kiln at a fineness of from 95 to 98 per cent. passing the No. 100 sieve is commercially practicable. The rotary kiln also enabled the American manufacturer to improve considerably the uniformity of the product, as this kiln burns very uniformly when properly handled and no sorting of the clinker is necessary.

While it is true that theory has not helped practice in the past, I am inclined strongly to believe that a solution of the question of the proximate composition of cements would be of practical importance and benefit. Perhaps the reason that the old theories have

not harmonized with, and made some impression upon, the practice of Portland cement manufacture is because of the fact that they were wrong. The true solution of the problem might open up many avenues of investigation which would lead to practical benefit and improvement of both the product and process of manufacture.

In spite of the uncertainty as to the proximate composition of Portland cement, the general influence of chemical composition upon physical properties is well understood among cement technologists; but this knowledge must be credited to practical experience rather than scientific theorizing. The controlling of the composition of the cement is nearly all of it done by rule of thumb methods, and each chemist employs the formula which practical experience has taught him best suits his conditions. The difference in raw materials and manufacturing conditions no doubt makes this necessary and no formula applicable to all cases has as yet been proposed.

Whatever may be the nature of their combination with each other the essential elements of Portland cement are lime, silica, and alumina. In the cements of commerce, iron replaces some alumina and magnesia some lime, since clays usually contain a considerable amount of the former, and limestones are rarely free from at least a few tenths of a per cent. of the latter. Other elements which are found in one or the other or even both of the raw materials and which find their way into the final product are the alkalis, manganese, titanate acid, phosphoric acid, sulphuric acid and strontium. Sulphate of lime, either in the form of gypsum, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, or of plaster of Paris (CaSO_4)₂ $\cdot\text{H}_2\text{O}$, is added to regulate the setting time, and carbon dioxide and water are absorbed from the air by the clinker, either before or after grinding. Of these elements, lime, silica, alumina, iron and sulphuric acid all exercise an important influence on the cement, and its properties will depend largely upon the relative amounts of these present. The alkalis, no doubt, if present in larger quantities, would affect to some degree at least the physical properties of cement, but in the small amounts found in American Portland cements the role they play is a very slight one. Table I gives the analyses of a larger number of American Portland cements from different parts of the country, and made from various raw materials. It will be seen that Portland cement in this country is made from four groups of materials:

(1) Cement Rock⁹ and Limestone.

⁹Cement-rock is an argillaceous limestone containing from 60 to 78 per cent carbonate of lime and from 15 to 30 per cent argillaceous matter. It is found in eastern Pennsylvania and western New Jersey only, in what is known as the "Lehigh Valley Cement Belt." Below are some analyses:

Locality	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	CaCO ₃	MgCO ₃
Nazareth, Pa.	11.10	1.24	4.42	77.60	4.17
Stockertown, Pa.	18.94	1.56	5.42	68.53	3.91
Siegfried, Pa.	17.32	2.04	7.07	68.91	4.28
Coplay, Pa.	14.71	2.10	6.61	69.54	5.11
S'w'rtsv'le, N. J.	16.16	1.25	6.98	70.38	3.90

⁸The words "ultimate composition" are here used in contradistinction to "proximate composition," the former meaning merely the percentage of certain elementary compounds that are shown to be present by chemical analysis, and the latter designating the relation which these bear to one another.

Table I.—Analyses of American Portland Cements.

(Made by the writer, except those marked *.)

Made From.	Where Made.	SiO ₂	Fe ₂ O ₃ , Al ₂ O ₃ .	CaO.	MgO.	K ₂ O.	Na ₂ O.	SO ₃ .	Loss.	
Cement rock and lime-stone	Nazareth, Pa.	19.92	2.28	7.52	62.48	3.19	0.52	0.66	1.51	1.46
	Nazareth, Pa.	21.14	2.30	6.94	63.24	3.26	0.36	0.51	1.12	1.24
	Bath, Pa.	19.64	2.80	7.52	62.31	3.04	n. d.		1.60	1.48
	Alpha, N. J.	21.82	2.51	8.03	62.19	2.71	n. d.		1.02	1.05
	Northampton, Pa.	21.94	2.37	6.87	60.25	2.78	0.61	0.87	1.38	3.55
	Coplay, Pa.	22.26	2.10	5.36	63.32	3.81	n. d.		.89	1.24
	Omrod, Pa.	22.20	2.27	6.69	62.61	3.00	0.32	0.61	1.32	1.56
	Martin's Creek, Pa.	20.32	2.50	7.12	62.94	3.38	n. d.		1.45	1.25
	Reading, Pa.	24.16	1.45	5.10	62.95	3.12	0.21	0.50	1.35	1.40
	Bay City, Mich.	20.74	2.85	7.17	62.64	1.97	0.48	0.12	1.42	2.58
Limestone and clay or shale	Wellston, O.	21.84	5.05	6.77	62.66	0.80	n. d.		1.24	...
	Chanute, Kan.	20.72	3.72	7.06	62.76	1.78	0.41	0.23	1.12	1.40
	Ada, Okla.	22.28	3.20	6.36	59.66	3.11	0.80	0.25	1.40	2.82
	*Stroh, Ind.	21.78	2.65	7.31	62.35	2.88	0.47		1.78	0.78
	*Glens Falls, N. Y.	21.50	10.50		63.50	1.80	0.40		1.50	n. d.
	Alsen, N. Y.	23.94	3.20	5.62	62.32	1.77	n. d.		0.90	1.68
	Frederick, Va.	21.31	2.81	6.54	63.01	2.71	n. d.		1.42	2.01
	Davenport, Cal.	25.38	1.20	3.34	62.96	1.20	n. d.		0.35	4.58
	Cement, Cal.	22.34	3.30	7.00	60.72	1.30	n. d.		1.05	2.54
	*Baker, Wash.	24.63	8.56		62.88	1.60	n. d.		1.33	n. d.
Marl and clay	St. Louis, Mo.	23.12	2.49	6.18	63.47	0.88	n. d.		1.34	1.81
	Demopolis, Ala.	19.36	4.10	9.18	63.20	1.16	n. d.		1.18	1.12
	*Portland, Colo.	21.88	2.85	7.14	64.94	trace	1.18		0.73	1.08
	*Middlebranch, O.	21.24	4.14	7.85	63.22	0.28	0.68		1.11	1.32
	*Coldwater, Mich.	21.22	3.83	7.51	63.75	0.82	n. d.		1.58	1.02
	Sandusky, O.	21.93	2.35	5.99	62.92	1.10	0.63	0.27	1.55	2.92
	*Bronson, Mich.	22.90	3.60	6.80	63.90	0.70	1.10		0.40	0.60
	*Harper,, Ohio	21.30	2.00	6.95	62.50	1.20	n. d.		0.98	4.62
	*Warners, N. Y.	22.04	3.41	6.45	60.92	3.53	n. d.		1.25	....
	Limestone and blast furnace slag	Chicago, Ill.	22.41	2.51	8.12	62.01	1.68	n. d.		1.40	1.02
		23.06	2.88	8.16	62.10	1.88	0.36	0.58	1.57	....

(2) Limestone and Clay or Shale.

(3) Limestone and Blast furnace Slag.

(4) Marl and Clay.

Referring to Table I, we see that the chemical composition of American Portland cements which pass the standard specifications for soundness, setting time and tensile strengths falls within the following limits:

	Per cent.
Silica	24—24
Alumina	5—9
Iron Oxide	2—4
Lime	60—63.5
Magnesia	1—4
Sulphur Trioxide	1—1.75

The average is represented by the following:

	Per cent.
Silica	22
Alumina	7.5
Iron Oxide	2.5
Lime	62.0
Magnesia	2.5
Sulphur Trioxide	1.5

The Lehigh Valley cements (made from argillaceous

limestone) are characterized by high magnesia usually between 3 and 3.5 per cent, though occasionally as low as 2.5 per cent and as high as 4 per cent. They contain about 2.5 per cent iron oxide and about twice as much silica as iron oxide and alumina combined. In those cements from the western end of the deposit, this ratio is somewhat higher, however, owing to the fact that the cement rock found here is higher in silica and also to the fact that the limestone used with this rock is silicious.

Most of the marl cements are low in magnesia, some of them containing as little as 0.5 per cent. Some of the Michigan marl cements are high in iron oxide, 3 to 4 per cent. This comes from the clay, or shale, however, and hence is also characteristic of some cements made from limestone and clay or shale.

The Alabama cements made from the Selma chalk at Demopolis are high in iron and alumina, published analyses showing 12 to 14 per cent iron oxide and alumina and only about 20 per cent silica.

Most American cements, which meet standard specifications, contain, when freshly made, from 60 to 63.5 per cent lime. Since cements absorb water and carbon dioxide on exposure to air, the percentage of lime

and also of all the other elements, except the two absorbed, is lowered by the seasoning or storage of the cement. In comparing the analyses of two cements, therefore, the amount of loss on ignition should always be considered, as a cement containing 63 per cent lime when fresh may contain 62 per cent or even less after exposure to air for a month.

The amount of lime a cement may contain is dependent upon both factory conditions and the relative amount of silica to iron and alumina present. The maximum of lime is usually controlled by the "soundness tests" (which are now, in America, the boiling and steaming of small pats of neat cement for five hours). The minimum of lime is determined by the setting time of the cement, which must be such that the cement does not get its initial set in less than 30 minutes, and also the strength which should be at least 450 lbs. neat and 150 lbs. sand per sq. inch.

Over-limed cements are "unsound," that is, in time concrete made from them will disintegrate and crumble or crack. Cements which are high in lime without being unsound are very slow setting but harden rapidly, sometimes reaching their maximum strength in as short a period as seven days. Such cements, when subjected to tension tests, usually show retrogression as the test pieces grow older, but, when subjected to compression tests, show an increase of strength with age. This is due to the fact that high lime cements become very brittle on hardening, hence when they are tested in the ordinary manner more or less distortion is met with, owing to the shortness of the test piece, and the briquette is snapped off, as it were, and not really pulled apart. Provided a cement is sound there is nothing in the theory so tenaciously held to by the school of engineers and chemists who borrow their ideas from the text-books of the past generation, that a cement must show a progressive gain. A cement which gets its strength promptly is certainly much better adapted to modern building conditions than one which requires a long period to reach the same point. With such a cement, forms can be more promptly removed and it is also suited to work in cold weather, such as in thin partitions and floors, where slower hardening cement would be impracticable, owing to the length of time during which it is **necessary to protect the work from the weather.**

Low lime cements are of low tensile strength and they are also, where the alumina is at all high, quick setting if the lime content is low enough, either when freshly made or after standing some time, consequently they must be heavily "dosed" with plaster.

The amount of lime a cement will safely carry is dependent on the relative amounts of silica and alumina present and also on the care with which a cement is made. Practically all American cements fall between two limits, i. e., the ratio of the lime to the silica, iron and alumina together should not exceed 2.1:1 nor be less than 1.9:1. To make a sound cement having the first ratio the raw materials must be well

mixed and very finely ground. Such a cement will be much stronger, however, than one having the lower ratio.

It is usually more or less unwise to speculate on insufficient data and the chemistry of cements has already suffered too much from such speculation, nevertheless the writer can not refrain from advancing the following hypothesis: That the lime in Portland cement clinker exists in three forms: *First*, in combination with silica, alumina, iron, etc., to form a magma of orthosilicates, $2\text{CaO} \cdot \text{SiO}_2$ ortho-aluminates, $2\text{CaO} \cdot \text{Al}_2\text{O}_3$, etc. *Second*, as the oxide itself in solid solution in this magma of silicates, aluminates, etc., and *Third*, as undissolved oxide; that is lime merely disseminated through the magma forming with the latter simply a mechanical mixture. If this is assumed, then it readily follows that it is the lime in the second condition which causes the hardening of cement mortars and the lime in the third form which promotes unsoundness. It is barely possible that in some cases with this third form of lime, the lime was at one time also in solution in the magma and crystalized out on cooling. Lime found under such conditions would probably be very slowly attacked by water and hence might easily not slake until after the mortar had hardened, thus causing expansion of the latter with consequent disintegration, distortion, checking, etc. In any event, low lime cements contain less of the active lime than high lime cements and overlimed cements contain the excess lime mechanically distributed through the clinker.

Anything which will promote the combination or solution of the lime during burning will promote soundness. Thus the finer the raw materials are ground the more surface of contact between the acid and basic elements exists, hence fine grinding of the raw materials is probably the most important requisite for the making of a sound cement. It is, of course, essential that the burning should be carried out at the proper temperature and be of sufficient duration to promote combination and solution. The greatest advance in the manufacture of Portland cement from the standpoint of quality has been in the introduction of more efficient grinding machinery, allowing the finer grinding of the raw materials and hence the manufacture of high limed, sound cements of great strength.

Silica and alumina, the other essential constituents in Portland cement, have also an equally important bearing on the strength. From the nature of things, cements high in alumina are low in silica and those low in alumina are high in silica. Cements usually contain 19 to 25 per cent silica and from 5 to 10 per cent alumina. High silica cements are usually slow setting and of good tensile strength. They harden also slowly and usually show a progressive gain. High alumina cements are apt to be quick setting and indeed if much more than 10 per cent alumina is present the cement is almost sure to be quick setting

even with the addition of sulphates. High alumina cements also are quick hardeners and consequently cements containing from $7\frac{1}{2}$ to 10 per cent alumina show high 7-day tests. Cements should contain at least 2.5 times as much silica as alumina. This ratio between the silica and the alumina the writer calls the *index of activity*, or

$$\text{Index of activity} = \frac{\% \text{ Silica}}{\% \text{ Alumina}}$$

This index should lie between 2.5 and 5. Cements with an index of activity of less than 2.5 are apt to be quick setting or else to become quick setting on exposure to air. In order to offset this tendency to set quickly on the part of high alumina cements, it is necessary to make them relatively higher limed than those containing moderate percentages of alumina. The high lime content gives slow setting properties which offset the quick setting ones due to high alumina. This is necessary in spite of the fact that silica combines with more lime than does alumina. If we assume both the silica and the alumina to be present as orthosilicates and orthoaluminates, then 1.9 parts lime combines with 1.7 times as much lime as alumina. On the other hand alumina increases the fluidity of the magma, and hence makes the cement more easily burned. Indeed cements high in alumina are hard to burn properly, owing to the fusibility of the calcium aluminate. This causes balling up and sticking together of the clinker in the hot zone of the kiln preventing uniform burning. It is also probable that alumina increases the solvent power of the magma for lime, and this allows the higher percentage of lime in high alumina cements.

Cements with an index of activity of more than 5 are usually very hard to burn. They are slow setting and also slow hardeners. Their early strength is often low but ultimately they obtain as great strength as other cements. There are a number of high silica cements on the American market which have great difficulty in meeting standard specifications as to 7-day strength.

Iron may be made to replace alumina to any extent. The iron in commercial cements acts as a flux, making the cement easier to burn. The color of cement is also due to iron. Cement made from materials containing no iron is perfectly white. It requires a higher temperature to burn, but when properly clinkered possesses all the setting and hardening properties of Portland cement. White Portland cements are now made at York, Pa., Canaan, Mass., and Kimmel, Ind. The plant at York, Pa., was started by Prof. S. B. Newberry, one of the best American cement technologists and is very complete. The writer recently examined some of this cement and his results follow:

Analysis.	Per cent.
Silica	23.56
Iron Oxide	0.32

¹⁰S. B. Newberry, *Cement Age*, IV, 38.

¹¹See also Campbell and White, *J. Am. Chem. Soc.*, XXVII, 1273.

Alumina	5.66
Lime	64.12
Magnesia	1.54
Sulphur Trioxide	1.50
Loss on ignition	2.92

Physical Properties.

Fineness through a No. 100 test sieve = 94.7%.

Fineness through a No. 200 test sieve = 76.9%.

Boiling test, 5 hours = Good.

Initial Set = 3 hours and 45 min.

Final Set = 6 hours and 30 min.

Tensile strength 1 day neat = 383 lbs.

Tensile strength 7 days neat = 627 lbs.

Tensile strength 7 days sand = 2.13 lbs.

Tensile strength 28 days neat = 755 lbs.

Tensile strength 28 days sand = 246 lbs.

A number of American Portland cements are quite low in iron and a few are very high. There is a very noticeable difference in the color of these extremes.

Iron does not make cement quick setting and may be made to replace alumina to advantage in many cases. Portland cement in which iron replaces alumina is claimed to resist sea water much better than ordinary cements.

A cement, called "Erz Cement," made from a silicious limestone and iron ore is manufactured by the Krupp Steel Co. at Hemmoor, Germany, and is intended for marine construction. It has about the following analysis:

Silica	20.5
Alumina	1.5
Iron Oxide	11.0
Lime	63.5
Magnesia	1.5
Sulphur Trioxide	1.0

This cement when mixed with plaster and exposed to the action of a concentrated sea water, of five times normal strength, under a pressure of 15 atmospheres, shows no trace of expansion and contraction. Ordinary Portland cement would be destroyed under such conditions in a few days. While laboratory tests do seem to indicate that the iron ore cement is proof against the corrosive action of sea water, it is by means certain that ordinary Portland cement mortar, properly proportioned, mixed and placed, will not also withstand the corrosive action of sea water. Dr. Rudolph Dyckerhoff, the distinguished German cement chemist, is the authority for the statement that concrete cubes, placed in the sea at Copenhagen in 1862, and taken out in 1902, were found to be entirely intact. The committee on the action of sea water on hydraulic cements of the German Cement Manufacturers' Association reported, at the last meeting of this association, that experiments begun in 1894 seemed to show that there was no marked difference in the behavior of cements, when used in sea water, between those containing 5 per cent alumina and those containing 8.5 per cent. This committee did find that

the interior surface of concrete cubes which had been in sea water since 1890 showed upon analysis 5 per cent less lime and 2 per cent more magnesia and sulphuric acid each then did the interior portions. In spite of this chemical reaction, however, the exterior surface was so hard that it was difficult to chisel it off.

In the face of such evidence, it is rather hard to believe that the mere fact that disks of neat Portland cement molded under pressure failed to stand immersion in boiling calcium sulphate solution is proof that Portland cement cannot be used in sea water. The writer has repeatedly contended that tests based purely upon theoretical considerations are always liable to lead to false conclusions. No test is entirely reliable until its results have been compared with the practical working of the material.

American engineering practice has not concerned itself with limiting the alumina in Portland cement to

and crack. Cements in which magnesia replaces lime are of low tensile strength because magnesium compounds have only faint hydraulic properties. A cement made from magnesite and slate had the following analysis:

Silica	27.84
Iron oxide and Alumina.....	11.16
Lime	2.02
Magnesia	56.20
Sulphur trioxide.....	1.42
Loss	0.86
Briquettes of this cement gave at the end of seven days a neat strength of 31 lbs. and at the end of one year a strength of 44 lbs., each figure being the average of five briquettes. Pats made of this cement passed satisfactory boiling and steam tests and the air and cold water pats at the end of two years showed no signs of expansion or cracking. A cement made of dolomite and slate had about 20 per cent the	

Table II.—Showing the Effect of Fineness of Grinding of the Raw Materials and Percentage of Lime upon the Soundness of Cement.

No.	SiO ₂ .	Analysis.		Mgo.	% CaO % SiO ₂ - % Fe ₂ O ₃ -Al ₂ O ₃ .	Fineness of raw Materials passing No. 100 sieve.	Soundness of cement.	
		Al ₂ O ₃ - Fe ₂ O ₃ .	CaO.				Boiling test.	Steam test.
A	20.84	9.62	63.12	3.06	2.07	98	Perfect	Perfect
B	20.60	9.76	62.91	3.04	2.07	94	Slightly checked	Fair
C	20.76	9.56	62.96	3.10	2.07	90	Disintegrated	Badly checked
D	20.18	9.28	64.62	2.88	2.19	98	Disintegrated	Badly checked
E	21.32	9.82	62.02	3.02	1.99	94	Perfect	Perfect
F	21.54	9.94	61.54	3.12	1.95	88	Disintegrated	Checked

NOTE.—These results are of actual mill work. Cement burned in rotary kilns and tested as soon as ground. Comparison of cements Nos. A, B and C shows the effect of fine grinding of the raw materials upon the soundness of cements of approximately the same composition, while comparison of cements A and D and of B and E shows effect of composition, where raw materials are ground to approximately same degree of fineness.

be used in sea water to a figure below that ordinarily met with in American Portland cement, but rather towards seeing that the cement to be used should conform to certain well tested specifications as to fineness, setting time, constancy of volume, tensile strength, magnesia and sulphuric acid, and also towards specifying the proper use of the cement; the careful proportioning of the aggregates to eliminate voids, and the thorough mixing and tamping of the concrete to secure homogeneity and density. The subject of the effect of sea water on concrete is now being very thoroughly investigated at the Boston Navy Yard by competent chemists and engineers.

Iron cement shows high tensile and compressive strength, provided it is very finely ground, otherwise it is very slow setting; in fact too slow setting for marine work. American Portland cement containing over 5 per cent iron can be obtained.

Replacing alumina by iron increased the specific gravity of Portland cement.

At one time magnesia was considered dangerous, now the standard specifications allow 4 per cent, and recent investigations place the limit above this. The popular supposition seems to be that magnesia in considerable amounts causes cement in time to expand

strength of one made of pure limestone and slate, both cements being made to agree with the formula:

$$\frac{\% \text{ magnesia} \times 1.4 + \% \text{ lime}}{\% \text{ silica} + \text{alumina} + \% \text{ iron oxide}} = 2$$

Dyckerhoff¹² on the other hand contends that cement containing over 4 per cent magnesia will expand and crack in time and gives numerous tests to prove his conclusions and also cites some instances of actual failure of concrete work made with cement high in magnesia. Nearly all experimenters agree that magnesia in cement has practically no hydraulic value. There are compounds of magnesia of great cementitious properties, however, one of which is the oxychloride of magnesia. This compound forms the base of Sorel cement, which is much stronger than Portland cement and finds use in such difficult work as the manufacture of emery stones. It has great powers of endurance and is said to withstand sea water. Some time ago the writer, acting upon the thought that if calcium chloride was added to cement this would form an oxychloride with the magnesia and convert the latter from a useless but necessary adulterant into an active cementitious compound, took out a pat-

ent¹³ upon the manufacture of Portland cement from materials high in magnesia by such addition of calcium chloride, the idea being that it would allow the use of native limestones, which are high in magnesia, with the cement rock. As no amount of limestone low in magnesia is found near the cement rock and the latter requires a mixture with it of from 10 to 30 per cent limestone, and as the magnesian limestones lie immediately adjacent to the cement rock, the value of the substitution of the native limestone for that coming from a distance can be well understood.

Cement made from cement rock and dolomite to which calcium chloride was added had the following analysis:

	Per cent.
Silica	21.94
Iron oxide and Alumina.....	10.66
Lime	55.72
Magnesia	6.59
Sulphur trioxide	0.38
Chlorine	1.06

The clinker ground easily and when pulverized to the usual fineness proved to have normal setting and hardening properties and passed perfectly the steam, boiling, cold water and air tests for soundness. It had the following strength when tested with three parts standard crushed quartz-sand:

7 days	298 lbs.
28 days	385 lbs.
3 months	426 lbs.
6 months	450 lbs.
1 year	475 lbs.

The question of the economic and satisfactory manufacture of Portland cement from materials high in magnesia is one of great importance in many parts of the world.

Magnesia lowers the clinkering temperature of the cement and hence makes a more fusible clinker, and a more easily burned cement. In view of the evidence recently collected, it seems safe to say that magnesia in cement does not cause unsoundness. At the same time it forms compounds of such weak hydraulic properties that it may be said to constitute an inactive substance and consequently an adulterant in cement unless some addition, such as calcium chloride, is made to the cement to form with it a cementitious compound.

The alkalies are present in cement only in small quantities. They probably, in the percentages present in most American Portland cements, have little or no influence on the properties of cement. They may act to some extent as a flux promoting the combination of the lime with the silica and alumina. At one mill soda-ash was for a time added for this very purpose. A large percentage of the alkalies present in the raw material is driven off, however, during the burning of

the cement.¹⁴ In an experiment which I made, which consisted in taking samples every three minutes for five hours of the raw material entering a 6x60 ft. rotary kiln, the clinker from the same and of the coal used to burn the latter, carefully analyzing the average samples and comparing these analyses it was found that from 19 to 28 per cent of the soda present in the raw material and from 46 to 52 per cent of the potash was volatilized during the burning. It has even been proposed to condense the alkalies present in the flue gases (as sulphates) and utilize them for fertilizers. The project, however, does not seem feasible under most conditions.

Additions of small quantities of either carbonate or hydroxide of potash or soda will cause cement to set quickly and if the quantity is increased to expand and crack on hardening. Where trouble is experienced owing to the presence of the alkalies in the cement, this trouble can often be eliminated by increasing the temperature of the burning, thus volatilizing the alkalies. The discontinuance of the manufacture of Portland cement from alkali waste and clay, in this country at least, was caused not by the presence of alkalies in the cement but from commercial and manufacturing reasons.

Calcium sulphate is added to cement either before or after grinding to delay the set. This is necessary as commercial cement clinker, if ground alone, will set very rapidly. Large amounts of calcium sulphate cause cement to disintegrate in time.

The standard specifications limit the sulphates which may be present in Portland cement to an amount equivalent to 1.75 per cent SO_3 . Calcium sulphate in any form may be used to retard the setting of cement.¹⁵ Gypsum and plaster of Paris are the ones generally employed; the former is added to the clinker before grinding and the latter to the ground cement before shipping. Calcium chloride may also be employed for the purpose of retarding the setting time of cement.¹⁶ There seem to be no objections to its use. It is at the present time obtained in large quantities as a by-product from caustic soda manufactured by the Solvay process. So far, the cost of collection and getting it into a marketable state is considerable, which has no doubt prevented its extensive use as a retarder. Calcium chloride prevents the freezing of mortar to which it is added during cold weather.¹⁷ It also adds to the water-proofing properties of mortar.

Additions of either calcium sulphate or calcium chloride will often cause unsound cement to pass the soundness tests and indeed to become sound. Much of the clinker now burned, if ground and tested without addition of calcium sulphate or calcium chloride, would show unsoundness, yet when tested after 2 or

¹⁴Meade, Papers, American Cement Manufacturers' Association, June 15th, 1904, also Chem. Eng., II, 221

¹⁵Meade and Gano, Chem. Eng., I, 92.

¹⁶Carpenter, Sibley Journal of Engineering, Jan., 1905.

¹⁷Meade, Engineering Record, Apr. 20th, 1907.

¹³Tonindustrie-Zeit., Feb. 2nd, 1908, Cement Age, Feb., 1909.

¹⁴U. S. Patent No 866,376.

3 per cent of either compound has been mixed with it, will prove perfectly sound.

Cement on exposure to air absorbs some carbon dioxide and water. These unite with the lime to form the carbonate and hydroxide respectively. The effect of such absorption is first of all to lower the specific gravity of the cement, since the specific gravity of cement itself is about 3.2, while that of calcium carbonate is only 2.8 and of calcium hydroxide only 2.1. The water and carbon dioxide seem to combine most rapidly with that portion of the lime in the cement which causes unsoundness, consequently seasoning unsound cements converts this lime to calcium carbonate and calcium hydroxide, both of which are harmless in cement and hence causes the cement to become sound.

Since cements containing a little lime in the free

less than one-half per cent loss on ignition, while perfectly well burned cements after storage but a short time, such as would naturally elapse between manufacture and use, may show 3 or 4 per cent water and carbon dioxide.

It is becoming the practice in the United States to season clinker in the open air in piles. This is done to make the clinker easier to grind. It also allows harder burning because such clinker can be ground as easily after such seasoning as a much softer burned one without it. The effect is also to lower the specific gravity by absorption of water and carbon dioxide.

The attempt was also made to regulate the set of cement by introducing steam into the tube mills and so do away with the addition of gypsum. The attempt does not seem to have been successful, and at

Table III.—Showing Effect of Chemical Composition on Tensile Strength.

No.	Analysis.							Tensile Strength—Neat.						Tensile Strength— $\frac{1}{2}$ Sand.					
	SiO ₂			SiO ₂ + Al ₂ O ₃ + MgO															
	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	Al ₂ O ₃	CaO	Fe ₂ O ₃	MgO	1 day	7 days	28 days	3 mos.	6 mos.	1 year	1 day	7 days	28 days	3 mos.	6 mos.	1 year
A	20.80	2.48	8.00	2.60	62.30	1.99	3.00	320	840	950	895	910	890	340	410	425	450	445	
B	21.02	2.40	7.54	2.79	61.53	1.99	3.45	210	828	921	910	905	945	325	415	410	460	475	
C	21.78	2.55	7.02	3.10	62.70	2.00	2.88	220	775	888	925	910	925	275	410	400	440	453	
D	22.20	2.98	6.26	3.55	62.85	2.00	2.10	245	635	740	755	785	835	225	335	388	410	440	
E	23.98	2.60	5.12	4.68	63.15	1.99	1.88	235	585	695	713	758	805	185	275	310	360	393	
F	24.42	3.10	4.22	5.79	62.86	1.98	1.57	210	510	645	666	710	755	165	245	283	298	335	
G	19.91	2.25	7.37	2.70	63.88	2.16	3.04	212	1048	968	945	955	960	330	395	375	380	395	
H	20.42	2.30	7.52	2.72	63.26	2.09	3.12	260	885	1004	995	1028	1036	345	435	458	485	510	
I	20.84	2.23	7.65	2.71	62.75	2.04	2.98	315	760	865	860	915	985	303	410	403	445	467	
J	21.20	2.35	7.85	2.70	62.13	1.98	3.06	310	710	825	815	888	903	260	338	360	388	403	
K	21.51	2.33	7.97	2.70	61.70	1.94	3.03	346	610	725	750	780	828	228	298	316	336	387	
L	21.94	2.38	8.10	2.71	60.95	1.88	3.16	410	525	610	625	675	713	193	260	285	310	345	

NOTE.—A comparison of cements A, B, C, D, E and F will show the relation between the relative percentages of silica and alumina upon the tensile strength. While a comparison of cements G, H, I, J, K and L will show the relation between the relative percentages of lime on the one hand and of silica, iron oxide and alumina on the other on the tensile strength.

state give high short time (one and seven-day) tensile strength tests, another effect of absorption of carbon dioxide and water is to cause low one and seven-day tests, but such seasoning does not seem to effect the 28-day test so much. Indeed, its most marked effect, if the cement is sound when fresh, is on the one-day tensile strength test.

Another effect which seasoning or absorption of these constituents has upon some cements (usually only those low in lime) is to cause them to become quick setting. If either slacked or unslacked lime is added to cements which have become quick setting, they are made slow setting, consequently it would appear that the effect of seasoning upon such cements has been to convert some of the hydroxide or oxide of lime to carbonate.

The amount of water and carbon dioxide in cement is no indication of the burning of cement, since clinker which is very markedly underburned often shows

any rate the mill where it was adopted soon abandoned the practice.

In concluding this paper, it may not be amiss to call attention to some of the formulas used by cement chemists for controlling the composition of their mixture of materials, etc. The problem of determining the probable composition of a cement from its raw materials is often put up to the chemist. The solution is by no means easy. The usual rule is to add together the percentages of silica, oxide of iron and alumina, lime and magnesia and to divide this sum into the percentage of each compound, multiplied by 100, for the percentage of that compound which will be present in the clinker. If this rule is followed, the results obtained for silica and for iron oxide and alumina will be too low and the lime much too high. This is because the ash of the fuel enters into the composition of the clinker and also because the clinker contains other constituents present in the raw materials

and not entirely volatilized in burning, viz., soda, potash, sulphur trioxide, etc., carbon dioxide and water.

To accurately calculate the composition of the clinker from the analysis of the raw material is, therefore, impossible, and the best we can do is to assume certain corrections. First of these is for the coal ash entering into the clinker. My own experiments show that in the rotary kiln about one-half the ash enters the clinker. The West Virginia gas slack coal contains about 10 per cent ash on an average. This ash is composed of about 40 per cent silica and about 20 per cent each of iron oxide and alumina. If, therefore, 90 lbs. of coal are required to burn a barrel of cement about 15 lbs. (equivalent to 1.5 lbs. of ash) are required per 100 lbs. of raw material burned. Assuming half the ash to enter the raw material, the silica in the latter is increased by $\frac{1}{2} \times 1.5 \times 0.40 = 0.30$ per cent, and the iron and alumina each by $\frac{1}{2} \times 1.5 \times 0.20 = 0.15$ per cent.

Analyses of Lehigh Valley clinker when fresh from the kilns show it to contain about 2 per cent of potash, soda, sulphur compounds, carbon dioxide and water combined. Clinker from other localities will probably not vary very widely from this.

Assuming the above corrections, my rule for calculating clinker from the mix analysis is as follows:

Add together the percentages of silica, oxide of iron, alumina, lime and magnesia. To the sum add 2.75. Call the result the "Clinker Total."

To find the percentage of silica, add 0.30 to the percentage of silica in the raw material, multiply the sum by 100 and divide by the "Clinker Total" as found above. The result will be the percentage of silica in the clinker.

To find percentage of iron oxide, add 0.15 to percentage of alumina in the mix, multiply by 100 and divide by "Clinker Total," etc.

To find percentage of lime or magnesia, divide percentages of these by "Clinker Total," etc.

EXAMPLE.

Analysis of Raw Material.

Silica	13.44
Oxide of Iron and Alumina.....	6.54
Lime	41.84
Magnesia	1.93

Correction for Ash, etc..... $\frac{2.75}{66.50}$

Clinker total 66.50

Percentage of Silica:

$$100 \times \frac{13.44 + .30}{66.50} = 20.66$$

Percentage of Iron Oxide and Alumina:

$$100 \times \frac{6.54 + .30}{66.50} = 10.29$$

Limestone (or Marl) $(\% \text{ SiO}_2 + \% \text{ Al}_2\text{O}_3 \text{ in Clay}) \times 2\frac{1}{4} - (\% \text{ CaO in clay})$

Clay (or Shale) $(\text{CaO in limestone}) - (\% \text{ SiO}_2 \times \% \text{ Al}_2\text{O}_3 \text{ in limestone}) \times 2\frac{1}{4}$

Percentage of Lime:

$$\frac{100 \times 41.84}{66.50} = 62.92$$

Percentage of Magnesia:

$$\frac{100 \times 1.93}{66.50} = 2.90$$

Probable composition of Clinker:

Silica	20.66
Iron Oxide and Alumina.....	10.29
Lime	62.92
Magnesia	2.90

Practically all American Portland cements satisfy the formula (Michaelis' "hydraulic modulus").

% Lime

$$= 1.9 \text{ to } 2.1$$

% Silica + % Iron Oxide + % Alumina

I have found that experimental work where the

Table II'—Showing Effect of Various Substances Upon the Setting Time of Portland Cement.

Percentage of substances added.	Plaster of Paris.		Gypsum.		Calcium Chloride.	
	Initial	Final	Initial	Final	Initial	Final
0	Set min.	Set min.	Set min.	Set min.	Set min.	Set min.
0.5	2	6	2	6	2	6
1	5	10	....	....	8	25
1.5	50	240	2	10	60	200
2	170	360	....	....	140	360
3	180	375	160	350	210	400
5	105	320	170	350	150	340
5	16	120	195	360	60	200

raw materials were ground to a fineness of 95 per cent through a No. 100 test sieve, I have never failed to make a sound cement, of normal setting properties and good strength when the composition of this cement met the ratio:

% Lime

$$= 2.05$$

% Silica + % Iron Oxide + % Alumina

provided the ratio between the silica and the alumina was not less than 2.5.

In mill practice, however, it is seldom that as high a ratio as this can be carried. Just what the ratio should be depends upon conditions of manufacture and the nature of the materials. When the alumina is low this ratio is often carried as low as 1.9 without obtaining quick setting cement. On the other hand, when the alumina is high it is often but not always necessary to carry the ratio as high as 2.05 to avoid quick setting cement.

The formula used to proportion the raw materials so as to give a cement having a ratio of 2.05 is as follows:

The additional 0.2 added in the formula is to take care of the small amount of coal ash which enters the cement.

Prof. S. B. Newberry proposed in 1897 the following formula based on the assumption that all the lime was present as tricalcium silicate and dicalcium aluminate:

$$\text{Lime} = \text{silica} \times 2.8 + \text{alumina } 1.1.$$

This was an attempt to solve the question from a scientific standpoint and to substitute for rule of thumb formulas one based on the then generally accepted theory of the composition of Portland cement. In practice the full amount of lime called for by the formula was never used, but instead only about 90 per cent of the theoretical amount. This formula would make a cement containing 23 per cent silica and 6 per cent alumina contain $(23 \times 2.8 + 6 \times 1.1) \times 0.9 = 63.45$, and one containing 21 per cent silica and 8 per cent alumina contain $(23 \times 2.8 + 6 \times 1.1) \times 0.9 = 60.8$. As a matter of fact there is no such difference between high silica and high alumina cements, as table 1 will show.

As matters now stand, therefore, it is hard to say just how to scientifically express the composition of Portland cement in mathematical formula. If it is simply a solution of lime in ortho-silicates and ortho-aluminates of lime, it seems highly probable that no mathematical formula will be devised, because the solubility of the lime in the magma may be greatly increased or decreased by both manufacturing conditions and the composition of the magma itself. The case seems analogous to that of steel where phosphorous promotes the solution of carbon and silicon causes it to separate from the solution. The sudden quenching of steel has its effect on the physical properties of the metal and similarly the sudden cooling of clinker by dropping it into water not only changes its color but also makes it slower setting and smoother trowelling. The very slow cooling of clinker sometimes causes it to dust, and cement made from such clinker is always unsound, possibly because during the slow cooling the lime dissolved in the magma separates from the solution.

The whole question is one more or less complex with only here and there a ray of light as to the reasons for the phenomena met with. That physical chemistry will soon solve the question of just what Portland cement is, all chemists engaged in the manufacture of this important compound sincerely hope. A sound theory would unquestionably prove the starting point for much scientific research towards the improvement of the product. At the present time such work is almost all of it directed along "hit or miss" lines and originates from observation rather than scientific reasoning.

Of the 37,000,000 hp. estimated to be available at the minimum flow of streams in this country, only 5,000,000 has been developed.

TESTS FOR TIN ORE.

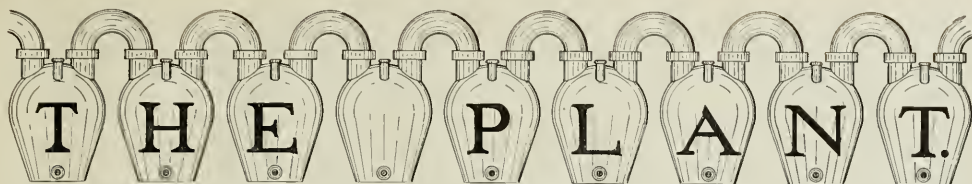
According to *Mineral Resources*, the simplest and easiest test for cassiterite is to place the mineral in dilute hydrochloric or sulphuric acid with granulated, sheet, or shot zinc. The zinc and the acid cause a rapid evolution of hydrogen, which takes the oxygen from the tin and leaves a coating of the metal upon the fragment tested. Hydrochloric acid and granulated zinc are best to use, as the evolution of hydrogen is very rapid and the zinc particles being small can be made to touch the specimen at many points and thus bring more of the hydrogen in contact with the tin-oxide molecules. The reaction is $4H + SnO_2 = Sn + 2H_2O$.

The metallic coating has a dull gray, somewhat lousy appearance as formed, but it may be made lustrous by rubbing with a soft cloth or the hand. In the latter case the familiar disagreeable odor given when tin is rubbed on the flesh is obtained.

This excellent method may be used upon specimens which it is desired not to injure, such as crystals or other choice pieces. However, the smooth surfaces of stream-polished wood-tin are roughened, owing to the impurities contained in the mineral, though the surfaces of ordinary crystalline cassiterite are not noticeably affected. After the test is made the metallic tin coating can be removed by immersing the piece in dilute hydrochloric, sulphuric, or nitric acid.

A better-known and often-used test, though one not so readily made, is the blowpipe test. The mineral supposed to be cassiterite is pulverized, and when so treated should yield a light-colored powder, unless mixed with iron oxides, in which case the powder will be reddish or brownish. A small portion of the powder is mixed with twice its bulk of pulverized charcoal and three times its bulk of sodium bicarbonate (ordinary baking or washing soda). The three substances are thoroughly mixed, and a portion the size of a pea is moistened and placed in a hollow in a piece of charcoal. On application of a reducing blowpipe flame tin is readily reduced in small globules, which are easily distinguished from the flux. After cooling the metallic globules may be separated from the soda and will be malleable. If large enough they will give the disagreeable tin odor when rubbed between the fingers, and will give a white precipitate when treated with concentrated nitric acid. They are soluble in hydrochloric acid, and no precipitate forms when the solution is cold. These reactions with acids differentiate the metal from lead.

The waters from the geysers of the Yellowstone Park have been subjected to analysis by the United States Geological Survey with a view to determine whether or not they are radio-active. Many of the springs show high radio-activity. These springs contain thorium and are the first to show this element in this continent.



THE WESTINGHOUSE GAS PRODUCER AND THE MANUFACTURE OF CLEAN GAS FROM BITUMINOUS FUELS.

A treatise on the subject of producer gas needs little or no introduction, so wide is the use and so generally known is this material. The problem of converting solid into gaseous fuel has been satisfactorily solved, and so far as its application in furnace heating is concerned, there appears to be but little room left for improvement. There are now, however, two very different methods of using producer gas, and consequently there are two very different kinds of producer gas made. It is used more commonly as a fuel, and as such the tarry matter and dust, normally present, are with few exceptions not objectionable. It is now being used to a rapidly growing extent as a "power gas," in which capacity it must be practically free from these ingredients. The development of the gas engine with its rapidly increased usage and possibilities has given to the gas producer industry a new impetus, creating the need for a more satisfactory solution of the problem of making gas free from tar and dirt.

It is comparatively easy to make a gas, suitable for internal combustion engines, from anthracite. The relative scarcity of anthracite, however, and its lack of wide dissemination, call for a power gas producer operating on bituminous coals and lignites. If bituminous coal is charged into an ordinary, updraft producer, such as is suitable for anthracite, the volatile hydrocarbons are driven off by the heat of the burning fuel, and the tar which they form upon condensation, must be removed before the gas could be used in the operation of an engine. While this could be done, it would be a source of unending annoyance, and it would not be economical, since the tar represents a large portion of the fuel value.

If the tarry vapors from a bituminous coal producer be subjected to a temperature corresponding to that of incandescent coke they will be broken up into free carbon and marsh gas (CH_4), which is a fixed gas at ordinary temperatures. Advantage is taken of this fact in certain types of producers which are built in pairs. Under regular working conditions, the charge in one of the units having been coked and in an incandescent state, the tar-laden gas from the top of the other unit, which has a charge of bituminous coal, is led down through the coke bed. As the coal in the one producer becomes coked, a charge of fresh coal is added to the other, and by a suitable valve arrangement the draft is reversed. While a good quality of gas can be made in producers of this design, serious

difficulties arise from the accumulation of ash and clinker, necessitating the stoppage of the plant while the fires are drawn for the removal of the clinker.

After some very extensive experiments and tests, at East Pittsburgh, the Westinghouse Machine Company have brought out a bituminous coal producer embodying the following qualifications: Continuous operation; producing a gas free from tar; operating at such temperatures as would avoid troublesome clinker formation; producing a gas of normal constituents suited to high engine compression; capable of being operated by a single attendant with comparatively little labor and skill.

The plan and elevation sections of the assembled apparatus are shown in Fig. 1. No attempt has been made to show an ideal or even a convenient disposition of the elements which go to make up the plant. The principal object has been to group them in such a way that they may all be brought within the limit of a single illustration.

The producer is shown on the left. Leading off to the right is the outlet pipe which conducts the gas to the scrubber. The lower end of the vertical section of this pipe is submerged in a pit through which the waste water from the scrubber passes, carrying off the heavier impurities in the gas. The gas passes up through the scrubber, and into the large horizontal cylinder or header. A positive exhauster is shown in connection with the vertical outlet pipe leading from the header. This may be driven by an electric motor or any other suitable means. The exhauster maintains a suction through the header and scrubber, back to the producer, so that the air and steam required by the latter are forced in by the pressure of the atmosphere. At the same time any desired pressure is maintained in the pipe line leading to the engines.

It is seen that in the discharge line there is a pipe leading back to the header. In this pipe is a butterfly valve which is operated through a series of levers by a gasometer, shown between the motor, which is on the extreme right, and the vertical discharge pipe. A small pipe connects from the gas line to the inside of the gasometer bell. The bell may be loaded by means of adjustable weights, so that it will rise when the pressure in the gas line tends to exceed any desired limit. If the demand for gas is diminished by reason of a reduction of the load on the engine, or for any other cause, the pressure in the gas line tends to increase, causing the gasometer bell to rise. This opens the butterfly valve, allowing a certain proportion of the gas to be by-passed back into the header. If the

demand for gas increases, the gasometer bell assumes a lower position, closing the butterfly valve to whatever extent is required to maintain the predetermined pressure in the gas line.

The header as shown is of considerable size, and is more conspicuous in a plant embodying only a single producer, than it would be in a plant made up of a battery of two or more producers.

With some varieties of coal—particularly the caking kinds—the gas as it comes from the producer for a

The general design of the Westinghouse Gas Producer for Bituminous Fuels, and the principle on which it operates will be readily understood by referring to the sectional view (Fig. 2).

Midway between the top and the bottom of the producer is a hollow annular casting, known as the vaporizer, which is kept filled with water to within several inches of the top. In this casting is a continuous ring-shaped passage communicating with the gas offtake pipe at the right and with the interior of the

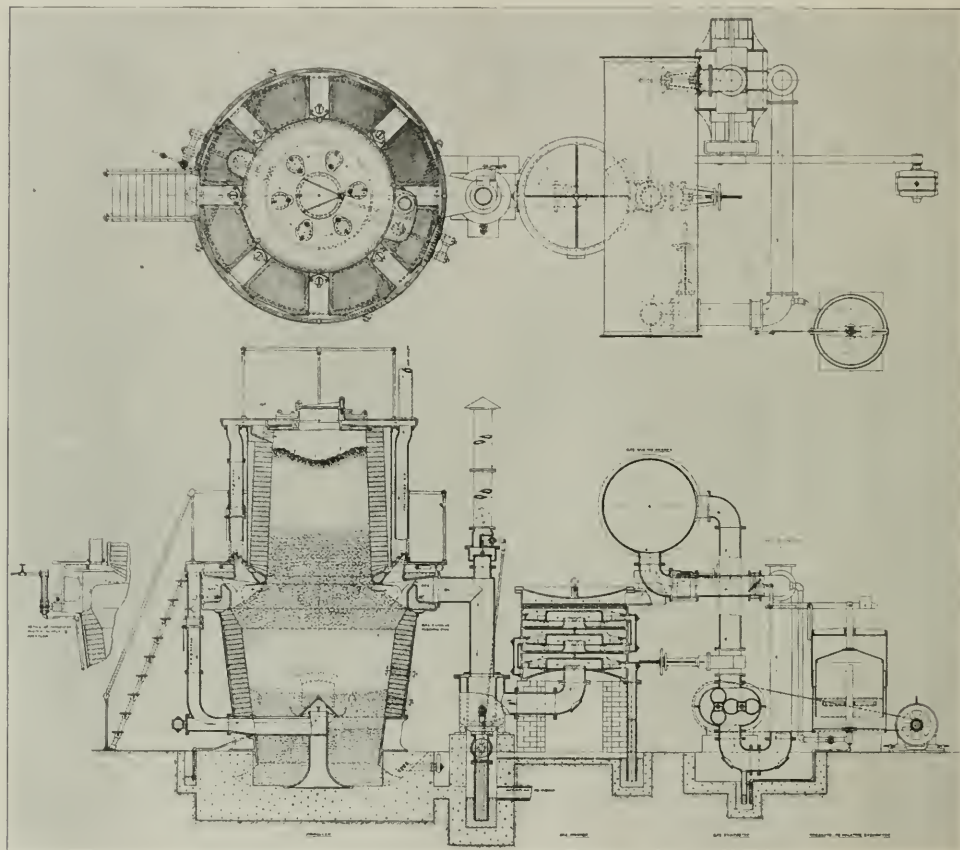


Fig. 1—Plan and Elevation Sections of Assembled Apparatus.

few seconds after the poking and charging operations, is apt to be richer than the average.

The continual by-passing of a portion of the gas back into a header of considerable volume keeps it well stirred up and insures a greater degree of uniformity in the quality of the gas as delivered to the engine. With a battery of two or more producers, the effect of the charging and poking operations on a single unit would have less effect on the entire system, and consequently the mixing header would be of very modest proportions.

producer by means of a number of ports. The top of the vaporizer overhangs inwardly to support the shell and lining of the upper section of the producer, which is materially less in diameter than the lower section. In fact, the outside diameter of the upper section is less than the greatest inside diameter of the lower section. This construction makes it possible to put poke holes through the upper surface of the vaporizer. These poke holes are the conical openings shown as extending downwardly and inwardly from the top of the vaporizer to the interior of the

producer. While only two of these poke holes are shown in the sectional view, there are six or more of them, depending on the size of the producer, distributed at regular intervals. The location of these poke holes is very advantageous as it enables the operator to reach all parts of the fuel bed in the lower section with comparatively short and light pokers.

The top of the producer has a hollow cast iron cover in the center of which is the charging door. In a circle outside the charging door is another row of poke holes through which the operator has command of the fuel bed in the upper section.

The chamber in the cover communicates with the atmosphere through the short vertical pipe extending upwards, and with the space above the water line in the vaporizer, through the vertical pipe shown at the right of the upper section of the producer.

At the left of the producer are shown two pipes connecting with the space above the water line in the vaporizer. One extends downwardly and leads into the tuyere in the lower section, and the other extends upwardly making communication with the interior of the producer above the fuel level.

A suction being created in the gas offtake pipe by means of the exhauster, air is drawn in through the short vertical pipe shown on the right at the extreme top of the producer. The air enters the hollow cover, and by means of a suitable deflector is compelled to

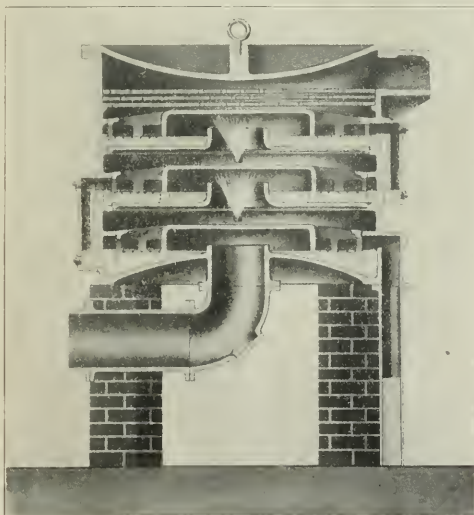


Fig. 2—Section Through Producer.

pass completely around it and out through the pipe leading to the vaporizer. The air passes over the surface of the hot water in the vaporizer, mixing with the steam that is generated, and passing off through the pipes on the left to the top and bottom sections to effect the combustion of the fuel. In each of the last mentioned pipes is a valve by means of which the flow

to the upper and lower sections of the producer may be adjusted to any desired quantity and in any desired ratio.

Between each of these valves and the interior of the producer is a valve or guaranteed cock opening to the atmosphere. In the illustration one cock is shown at

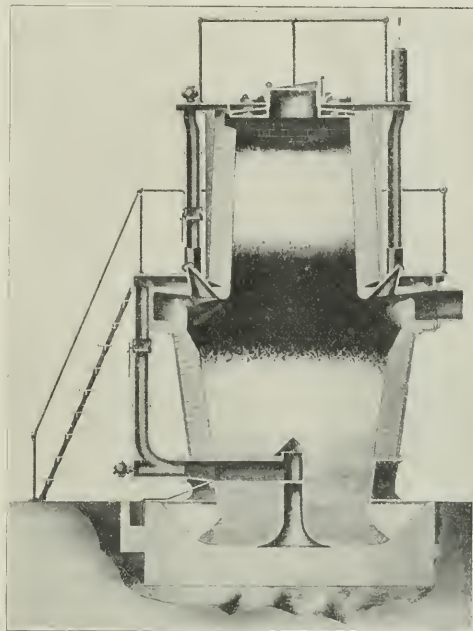


Fig. 3—Section Through Washer.

the left-hand end of the horizontal pipe connecting with the tuyere, and the other is shown at the extreme left of the producer top communicating with the port leading to the upper section. The exact location of these valves is immaterial, so long as they are beyond the valves controlling the flow from the vaporizer. By suitable adjustments of the valves controlling the flow from the vaporizer and the cocks communicating with the atmosphere the degree of saturation of the air entering the producer is under complete control.

The required degree of saturation is always clearly indicated by the condition of the fire. If it burns too hot and tends to clinker, an increase in the amount of vapor admitted with the air will quickly correct this tendency. If the fire is too sluggish, and the quality of the gas falls off, the proportion of vapor should be reduced.

There is no grate in the producer. The bottom is submerged in a water seal formed by a basin in the concrete foundation, the whole structure resting on several piers extending inwardly from the edge of the basin.

There is ample space between the bottom of the producer shell and the bottom of the water basin to

permit the ready removal of ash and clinker. When one sees the ashes removed without dust or heat, no further exposition of the desirability of the water-sealed bottom is necessary.

Near the bottom of the lower shell are three rows of sight holes at different levels, through which the condition of the lower fuel bed may be inspected, to determine when it is desirable to remove ash. The fire should always show bright at the upper level, and at the lowest level nothing but ash should be visible. If the fire looks dull at the upper row of sight holes, ash should be removed until the fuel bed settles far enough to show fairly bright at the middle row, but not enough to show at the bottom row.

Usually it is sufficient to remove the ashes once every twelve hours. The operator soon learns just how much to take out, and the best time for doing it, so that in any individual plant, the operation quickly becomes a mere matter of ordinary routine.

The upper level of the fuel bed is about two feet below the top of the producer. When fresh coal is charged in through the opening in the cover, air and a little steam entering above the fuel bed cause the coal to ignite, and the volatile constituents to be driven off. As the draft through the upper section is downwards, these volatiles are drawn through the hot fuel and disintegrated, and the greater part of the lampblack is filtered out in the fuel bed.

Very little combustion of the fixed carbon takes place in the upper section, the residue consisting almost entirely of coke.

The shading of the fuel bed is intended to give a rough idea of the comparative temperatures in the different parts of the producer, the darker portions representing lower temperatures. The first ignition causes a high heat just below the freshly charged fuel. On account of the heat required for breaking up the hydrocarbons the temperature gradually decreases toward the lower end of the upper section.

The resulting coke, by reason of the periodic removal of ash, passes down into the lower section which acts as a simple updraft producer. The coke in its descent gets gradually hotter, accomplishing its task of transforming the rising current of CO_2 into CO , and of dissociating the steam admitted with the air, and is finally burned completely to ashes.

THE WASHER.

The washer, shown in section in Fig. 3, is a cylindrical cast iron shell divided by horizontal diaphragms into three compartments.

The gas enters at the bottom under a cast iron bell, the lower edge of which is submerged in water. Extending outwardly from this bell, and beneath the water level in the compartment is a finely perforated metal plate. The gas forces its way under the edge of the cast iron bell, and passes up through the perforated plate which divides it into very small bubbles. These bubbles pass up through about one inch of water. The gas then passes up through the center of the first

horizontal diaphragm, under a second cast iron bell, and through a second perforated plate covered with water. This operation is again repeated, and the gas finally passes through a wooden grid and out through the opening shown at the right-hand side.

The division of the gas into small particles in passing through the perforated plates, makes the contact with the water very thorough, so that both cleaning and cooling are effected in a most efficient manner.

Water is introduced by spray nozzles as indicated in the engraving, and the overflow from the top compartment passes in to the middle compartment through the connection shown at the right just below the gas outlet. From the middle compartment the water overflows into the lower compartment through a similar connection shown on the left. From the bottom compartment it passes out through the water sealed waste pipe shown at the right. There are adjustable weirs at the overflow from each compartment, in order to maintain any desired depth of water over the perforated plates.

To determine the efficiency of a producer we must know not only the number of pounds of coal consumed and its thermal value, but we must know the total number of cubic feet of gas made, and the heat value per cubic foot. When we consider that it requires from 80 to 90 feet of good producer gas to develop a brake horse power hour with a first-class gas engine, it will be easily understood that an accurate gas meter of sufficient capacity to measure the output of a moderate sized producer plant is a little too cumbersome and expensive a piece of apparatus to be ordinarily included as a part of the regular equipment. Even though such a meter could be borrowed, the expense of transportation and temporary installation would be serious enough to make one willing to accept a good deal on faith. Then comes the question as to whether the so-called "total" or the "effective" heat value of the gas is to be used in calculating the efficiency, a question that will be a bone of contention between the engine builder and the producer builder just as long as we refrain from regarding the engine and the producer as integral parts of one piece of apparatus. Whether the heat value of the gas be measured by a combustion calorimeter or computed from chemical analysis, the instruments required, their manipulation and the mathematical calculations involved, are as yet regarded as matters more within the domain of the chemist than of the engineer.

Taking everything into consideration, the giving of especial prominence to the results of several tests as expressed in pounds of coal per brake horse power per hour seems warranted.

These tests were run on a producer having a nominal rated capacity of 175 horsepower, and a Westinghouse Three Cylinder Vertical Gas Engine. The engine is nominally rated at 140 brake horsepower, but has a liberal overload capacity.

Test A. Intermittent Operation, Fuel, Pittsburg hi-

tuminous coal, averaging 13,305 B. t. u. per pound as fired. This test was run for fifteen days, the engine operating ten hours each day except Saturdays when it was shut down from noon until the following Monday morning. This test is peculiarly significant inasmuch as, with the exception that a constant load was maintained, the operating conditions were very similar to those prevailing in many small manufacturing plants, and the coal consumption includes all of the standby losses.

SUMMARY.

Engine operating	128.5	hours
Producer standing by.....	241.5	hours
Total coal fired.....	27,157	pounds
Average load	158.5	B. H. P.
Gross coal per B. H. P. hour.....	1.34	pounds

Test B. Continuous Operation, Fuel, Pittsburg bituminous coal averaging 13,305 B. T. U. per pound as fired. Test was run continuously for 298 hours or 12 days and 10 hours.

SUMMARY.

Engine operating	298	hours
Total coal fired.....	53,925	pounds
Average load	158.3	B. H. P.
Gross coal per B. H. P. hour.....	1.14	pounds

Test C. Continuous Operation, Fuel, Northern Colorado lignite averaging 9,589 B. T. U. per pound as fired. Test was run continuously for 314 hours, or 13 days and 2 hours.

SUMMARY.

Engine operating	314	hours
Total coal fired.....	60,740	pounds
Average load	121.7	B. H. P.
Gross coal per B. H. P. hour.....	1.59	pounds

A comparison of tests B and C is interesting as showing the uniform efficiency of the plant with widely different qualities of fuel. If we multiply the heat value of the coal used on test B by the pounds consumed per brake horsepower hour, and divide by the thermal value of the coal used on test C the quotient is practically identical with the coal consumption per brake horsepower on test C.

$$\frac{13,305 \times 1.14}{9,589} = 1.58.$$

Tests A, B and C have an added interest in the fact that they cover an unusually long period, and the consumption of a large quantity of coal, so that errors due to a difference between the initial and final conditions of the fuel in the producer are practically eliminated.

Tests D, E, F and G, Continuous Operation, Fuel, Pocahontas coal averaging 13,983 B. T. U. per pound as fired. This series is interesting as showing comparative efficiencies at various loads.

TEST D. SUMMARY.

Engine operating	46.5	hours
Total coal fired.....	4,849	pounds
Average load	75.6	B. H. P.
Gross coal per B. H. P. hour.....	1.38	pounds

TEST E. SUMMARY.

Engine operating	48	hours
Total coal fired	6,065	pounds
Average load	126.3	B. H. P.
Gross coal per B. H. P. hour.....	1.25	pounds

TEST F. SUMMARY.

Engine operating	48	hours
Total coal fired	6,403	pounds
Average load	126.3	pounds
Gross coal per B. H. P. hour.....	1.06	pounds

TEST G. SUMMARY.

Engine operating	72	hours
Total coal fired	10,699	pounds
Average load	149.2	B. H. P.
Gross coal per B. H. P. hour.....	0.996	pounds

These four tests were run with no intermission between them, so that by combining them we get a continuous test of nine days of 24 hours daily operation with load varying between 50 and 100 per cent of the normal capacity of the engine.

TESTS D, E, F AND G COMBINED. SUMMARY.

Engine operating	214.5	hours
Total coal fired.....	28,016	pounds
Average load	112.3	B. H. P.
Gross coal per B. H. P. hour.....	1.112	pounds

Tests H and I. Continuous Operation, Fuel, Texas lignite from the Hoyt district, averaging 8,007 B. T. U. per pound as fired. This series is noteworthy on account of the character of the fuel. This fuel is, from a geological standpoint, the newest formation that can be classed as a coal. It contains an unusually high percentage of moisture and volatile matter, and its appearance unmistakably indicates its recent vegetable origin.

A comparison of the analyses of this Texas lignite and Pocahontas coal will be interesting as showing the differences between the two extremes of fuels of the general bituminous type.

COMPARATIVE PROXIMATE ANALYSES.

	Texas Lignite.	Pocahontas.
	Per cent.	Per cent.
Moisture	23.83	1.39
Volatile matter	38.32	16.01
Fixed carbon	29.22	74.28
Ash	8.63	8.32
B. T. U. per lb. as fired..	8,007.	13,983.

The moisture in this sample of lignite is unusually low, as much of it was evaporated in transit from Texas and in storage during a considerably long period of unusually dry weather. At the mines this fuel often shows over 30 per cent of moisture, which would correspondingly lower its thermal value as fired.

TEST H. SUMMARY.

Engine operating	72	hours
Total coal fired	16,970	pounds
Average load	128	B. H. P.
Gross coal per B. H. P. hour.....	1.85	pounds

TEST I. SUMMARY.

Engine operating	46.5	hours
Total coal burned	12,693	pounds
Average load	151.5	B. H. P.
Gross coal per B. H. P. hour.....	1.80	pounds

Test J. Fuel, Pocahontas Coal averaging 13,983 B. T. U. per pound as fired.

Duration	96	hours
Total coal fired	14,452	pounds
Heat value per pound.....	13,983	B. T. U.

Total heat input = $14,452 \times 13,983 = 202,082,316$ B. T. U.

Total gas made (corrected to 62° F. and 30 ins. barometer) 1,273,901 cu. ft.

Total heat value of gas per cu. ft. 126.9 B. T. U.

Effective heat value of gas per cu. ft. 117.8 B. T. U.

Total output 161,658,037 B. T. U.

Effective output 150,065,539 B. T. U.

Efficiency, total = $\frac{150,065,539}{202,082,316} = 80$ per cent.

Efficiency, effective = $\frac{150,065,539}{202,082,316} = 74.5$ per cent.

Test K. Fuel, Texas Lignite averaging 8,007 B. T. U. per pound as fired.

Duration	46.5	hours
Total coal fired	12,693	pounds
Heat value per pound.....	8,007	B. T. U.

Total heat input = $12,693 \times 8,007 = 101,632,857$ B. T. U.

Total gas made (corrected to 62° F. and 30 ins. barometer) 612,361 cu. ft.

Total heat value of gas per cu. ft. 128.3 B. T. U.

Effective heat value of gas per cu. ft. 117.1 B. T. U.

Total output 78,565,816 B. T. U.

Effective output 71,707,463 B. T. U.

Efficiency, total = $\frac{71,707,463}{101,632,857} = 77.3$ per cent.

Efficiency, effective = $\frac{71,707,463}{101,632,857} = 70.5$ per cent.

In each case the gas was measured by a positive displacement type of meter which was carefully calibrated. The heat values of the gas were determined by hourly analyses, 96 in test F and 47 in test K. The aspirator for drawing off the gas sample operated continuously, so that each sample is an average of all of the gas made during the hour in which it was collected.

The combustion of hydrogen forms water. The heat evolved evaporates this water into steam. The latent heat of the steam cannot be recovered unless the products of combustion are cooled to a temperature

below 212° Fahrenheit, which is a condition that never obtains in a gas engine. Builders of gas engines in reckoning the heat consumption in their engines have demanded credit for that portion of the heat that goes off as steam in the exhaust, and which could not be utilized in the engine. Hence for all gases containing hydrogen, it is usual to give two heat values—the total which includes the latent heat of the steam resulting from the combustion, and the effective, which omits it.

TEST J. GAS FROM POCAHONTAS COAL. Per cent.

Carbon dioxide (CO ₂)	7.9
Oxygen (O)	0.5
Carbon monoxide (CO)	18.1
Marsh gas (CH ₄)	2.6
Hydrogen (H)	12.6
Nitrogen (N)	58.3
Total heat value per cubic foot.....	126.9 B. T. U.
Effective heat value per cubic foot.....	117.8 B. T. U.

TEST K. GAS FROM TEXAS LIGNITE.

Per cent.

Carbon dioxide (CO ₂)	12.4
Oxygen (O)	0.9
Carbon monoxide (CO)	13.3
Marsh gas (CH ₄)	3.6
Hydrogen (H)	14.7
Nitrogen (N)	55.1
Total heat value per cubic foot.....	128.3 B. T. U.
Effective heat value per cubic foot.....	117.1 B. T. U.

A higher amount of CO₂ seems, for some reason, to result from the use of fuel containing high percentages of moisture and volatile matter.

These gas analyses are actual, and are not computed possibilities. The large number of samples going to make up the average, and the manner of taking the samples as described in connection with efficiency tests J and K, insure that the results are dependable and that they represent a true average.

By taking "snap" samples at judiciously selected times, more attractive analyses may be easily obtained, but these would in no sense be indicative of the results one might hope to obtain in regular operation.

The heat values are computed on the assumption that the gas is at a temperature of 62° Fahrenheit. Some people assume a temperature of 32° at which temperature the gas would be enough denser to increase its heat value about 6 per cent. As we never get producer gas at temperatures reasonably approaching 32°, the question as to what its thermal value would be at that temperature is not of much interest to the practical engineer.

The average of 40 tests on gas made from Texas lignite shows 0.01035 grains of solid matter per cubic foot, and the average of 21 tests made from Pocahontas coal, 0.00990 grains. After the engine on which these tests were made had run over a thousand hours, it was found on examination that the valves and gas passages were not fouled badly enough to require cleaning.

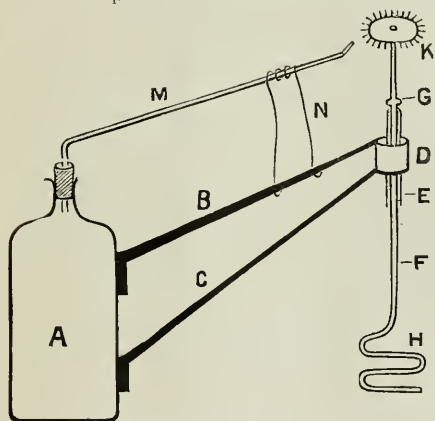
THE LABORATORY

A SIMPLE MECHANICAL STIRRER.

By DOUGLAS H. B. COUMAN.

Having recently devised a mechanical stirring apparatus which may be perhaps novel, a description may be of use to your readers.

A is a cylindrical copper boiler (1 liter) to which are soldered brass tubes, *B* and *C*, 20 cm. long; these support a piece of wide brass tubing, *D*, which is fitted with a cork through which a glass collar, *E*, is vertically fixed. *F* is the stirring rod enlarged to a smooth disc at *G*; before bending at *H* the glass collar, *E*, is slipped over the rod. *K* is a circular cork, being 5 cm. diameter and 1 cm. thick. It carries a number of vanes of zinc plate $\frac{1}{2}$ mm. thick, and projecting from the cork about 1 sq. cm. The vanes are inserted into slits



made in the cork by means of a razor; they should be placed about 1 cm. apart around the circumference, at an angle of 30° with the vertical, so that the steam from the glass pipe, *M*, will exert a lifting as well as a rotating force, thus diminishing friction at *O*. The adjustment is most conveniently made by altering the shape and jet of the glass pipe, *M*. My own jet is inclined upwards, the vanes passing directly over it, and has an internal diameter of rather less than 1 mm.

N is a piece of string which holds the glass tube in a slightly strained position and diminishes its vibrations.

Using a Barthel spirit lamp steam is ejected with enough force to rotate the stirrer rapidly in a 50 per cent solution of sugar. No lubricant is required. Steam does not condense on the vanes, and does not interfere with the liquid which is being stirred.

A safety valve would be an obvious improvement.

METHODS FOR THE DETERMINATION OF VANADIUM.

The importance which has recently been attained by the element vanadium in metallurgy has caused considerable research into rapid and accurate means for its determination. Two recently published volumetric methods are given below. The first of these was worked out by Mr. H. F. Watts of Boulder, Colo., and appeared in the *Western Chemist and Metallurgist* for November. The second is a colorimetric one devised by Mr. Arnold Wm. Gregory, an English chemist, and was published in a recent issue of *Chemical News*.

Watts's Method.

Method for Products Low in Silica.—Weigh out from 0.250 to 1.000 gram of the finely powdered material and mix in a nickel crucible of about 25 cc. capacity with 3 grams of sodium peroxide; cover with about 1 gram more of the peroxide and heat over a Bunsen burner for three or four minutes. It is not necessary to heat to fusion; a dull red being sufficient. When the darkening which gradually takes place on the surface is complete, the operation may be considered finished.

Fill a 500 cc. beaker half full of cold water and transfer the cold crucible containing the melt to it. Care should be taken at this point as the reaction between the peroxide and water is violent. It is well to float the crucible in the beaker, cover with a large watch glass and add water to the contents of the crucible a few drops at a time from a wash bottle. When solution is complete, remove and wash the crucible, heat to boiling and pass a current of carbon dioxide through the solution until saturated. Remove from the heat, allow to settle and pour through a filter supported on a platinum cone. Wash three times by decantation and three times on the filter using hot water containing a little sodium carbonate. Suction can be applied toward the end of the operation if found necessary.

The filtrate is brought just acid with nitric acid, boiled and the vanadium precipitated with lead acetate; the slight excess of nitric acid being corrected by the addition of a gram or two of sodium acetate.

The precipitate of vanadate of lead is separated by filtration, and dissolved in a small quantity of dilute nitric acid. To the solution add 10 cc. concentrated sulphuric acid, evaporate to fumes, cool, add cold water and separate the sulphate of lead by filtration, catching the filtrate in a flask. The filtrate which may amount to 150 cc. is boiled and reduced by sodium sul-

phite, using 1 gram and adding in successive small portions. The excess of sulphur dioxide is removed by boiling; for convenience in testing this point, fit a stopper and delivery tube to the flask. When the escaping steam no longer decolorizes a dilute solution of permanganate of potash, held in a small beaker, the boiling is stopped and the hot solution titrated with standard permanganate.

The iron factor multiplied by 0.916 equals vanadium.

If the material contains arsenic, it will be necessary to remove it. A convenient point at which to do this is after the first reduction by sodium sulphite. Pass hydrogen sulphide, filter, boil out excess and titrate.

A correction from the burette reading should be made as follows: To 150 cc. of water in a flask, add 10 cc. sulphuric acid and 1 gram sodium sulphite. Boil out the sulphur dioxide and titrate. The amount of permanganate used to color the solution should be deducted from the assay. This correction usually amounts to 0.2 cc.

Method for Ores.—Treat 1 gram of the finely ground ore (less if high grade) with 10 cc. of aqua regia and evaporate to dryness. Add 10 cc. nitric acid, 1.20 sp. gr., and digest on the hot plate for a few minutes. Filter off the silica, etc. Nearly neutralize the filtrate with caustic soda and pour it with constant stirring into a hot solution of caustic soda contained in a large beaker. A stick of caustic soda dissolved in 200 cc. of water is about the right strength. Heat the solution to boiling and pass a current of carbon dioxide gas. From this point the method is carried out as described above.

For Products Containing Much Silica, not readily decomposed by acids, the method of heating with sodium peroxide may be used, but in this case it will be necessary to remove the silica. The filtrate from the iron, after slight acidification with nitric acid, is made alkaline with ammonia and three or four grams of ammonium carbonate added. The beaker is put on a warm plate and allowed to stand for an hour with occasional stirring. The voluminous precipitate of silica is separated by filtration on a 12 cm. filter supported on a platinum cone using suction. This precipitate, although somewhat inclined to be sticky, is not difficult to filter if suction is used. The washing with hot water, containing a little ammonium carbonate, must be thorough. Ten or twelve times is not too much, churning up the precipitate well with the stream from the wash bottle. The filtrate now freed from the greater part of the silica is again made slightly acid with nitric acid and the precipitate with lead acetate made as before.

When using the acid method of decomposition, it is not always safe to assume that the vanadium is all extracted by treatment of the ore crushed to 80 mesh or coarser, with dilute nitric acid, as is sometimes recommended. Some vanadiferous sandstones yield to this treatment, but not all and the writer has repeatedly found vanadium in residues treated in this manner.

To make sure of complete extraction, the ore should be finely ground in an agate mortar and decomposed first with aqua regia.

The direct reduction and titration of the vanadium in the presence of the accumulated salts of the analysis is inaccurate, the end point being uncertain and successive reductions generally failing to check; so it is always necessary to separate the vanadium from these by precipitation with lead acetate, the titration of pure vanadium solutions being exact. If rapid approximate results are wanted, the filtrate from the iron residue may be acidified with sulphuric acid and the solution reduced and titrated.

The method as described has the advantage over the ammonium carbonate method in that the separation of the iron and vanadium is performed, in nearly every case, at a single operation, and obviates the necessity of a resolution and reprecipitation of the iron residue. A clean separation can be made on iron vanadate using 300 mgs. of substance.

The carbon dioxide is used to prevent bumping, although in some cases its use apparently gives a cleaner separation, due possibly to the tendency of the alkaline carbonates formed to hold vanadium in solution.

Gregory's Method.

This method is intended for the determination of very small quantities of vanadium and has given good results in Dr. Gregory's hands.

Mandelin's reagent (a solution of vanadic oxide in sulphuric acid) is in general use for the detection of alkaloids. With strychnine this reagent gives a violet coloration which gradually changes to an orange tint.

Inversely, the author has found that a solution of strychnine in concentrated sulphuric acid not only affords a means of detecting small quantities of vanadium in the presence of titanium, molybdenum, and tungsten, but also may be used in the quantitative estimation of that element.

The solution of strychnine used contains 4 grms. of pure strychnine in a liter of concentrated sulphuric acid.

A standard solution of vanadium is made by dissolving 0.1778 gm. vanadic oxide in 10 cc. of concentrated sulphuric acid, and diluting to liter (1 cc. of this solution contains 0.0001 gm. vanadium).

To a measured portion of the solution to be tested 20 cc. of concentrated sulphuric acid are added, together with a small crystal of potassium chlorate to oxidize the vanadium to V_2O_5 . The solution is evaporated until white fumes of sulphuric acid are given off and chlorine dioxide is no longer evolved.

A measured quantity of the standard vanadium solution is treated in an exactly similar manner.

When the solutions are quite cold, 20 cc. of the strychnine solution are added to each. A deep violet color is at first produced, which changes gradually to an intense orange. The solutions are allowed to stand for ten minutes, by the end of which time no further change is visible. The colors are then compared by

transferring the solutions to stoppered comparison tubes of similar dimensions, the beakers being rinsed out with a little concentrated sulphuric acid.

The solution showing the more intense color is then diluted with concentrated sulphuric acid until no difference of tint is discernible in the two tubes when viewed against a semi-opaque white glass screen.

Since the amount of vanadium in the measured quantity of the standard solution is known, the amount in the other tube can be calculated by comparing the heights of the solutions in the two tubes. It is more accurate to proceed in this manner than to compare the volumes of the solutions, as any error due to the irregularities in the bore of the comparison tube is eliminated.

A convenient comparison tube is one 12 inches long and $\frac{3}{4}$ inch internal diameter.

Using such a tube a convenient color for comparison is obtained by 0.0005 gm. of vanadium diluted until it occupies about half the volume of the comparison tube.

The best results are obtained when the amounts of vanadium in the two solutions compared are approximately the same. It is advisable, therefore, if there is a wide difference in the colors in a preliminary test, to make a second test, using such quantities that the tints approximate.

The presence of large quantities of titanium, molybdenum, tungsten, or aluminum do not affect the test.

Iron, if present, must be removed, as in large quantities it entirely prevents the formation of the color. When iron is present the substance to be tested should be fused with sodium carbonate, extracted with water, and filtered. The filtrate is then made up to a definite volume and a measured portion tested as described above.

If the strychnine solution is added to an aqueous solution of a vanadic salt, the color produced is less intense. It is therefore necessary to carry out the tests under exactly similar conditions to those indicated above.

It is essential that the vanadium should be in the highest state of oxidation (V_2O_5), as salts of the lower oxide (V_2O_4) do not give the color test.

PREPARATION OF INFUSORIAL EARTH FOR THE MARKET.

In Europe, especially in Germany, infusorial earth has found extended application. The material is first roasted superficially in large rooms in order to destroy all organic matter and to expel nearly all water present. It is then transferred to flame or muffle furnaces and heated at a higher temperature. Care is observed, however, not to raise the temperature too high, as the absorptive power is destroyed by overburning. The earth is then ground to a fine powder between rollers and sieved; at this stage it should contain less than 1% of moisture. The product is put into sacks and used the same day or before moisture can be reabsorbed.

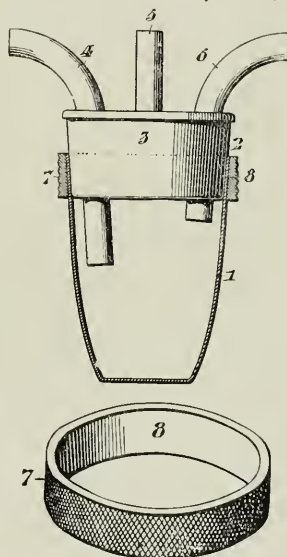
A SIMPLIFIED COMBUSTION CRUCIBLE.¹

By PORTER W. SHIMER.

Consulting Chemist, Easton, Pa.

In 1899 the writer published a paper² describing an ordinary platinum crucible which, for combustion purposes, could be closed by means of a water-cooled brass stopper fitted with a rubber band and provided with inlet and outlet tubes. In 1901 he described a special water-jacketed crucible³ to be used in connection with the water-cooled stopper. This latter form has come into rather extensive use. A disadvantage, however, is its rather high cost, the 60 cc. size weighing about 92 grams; it is also rather difficult to manufacture and repair.

In the latest form of the apparatus⁴ the crucible is a simple one, without the water jacket. It is 60 cc. capacity, rather deep in form, and weighs only 50 grams. When provided with an ordinary cover, to be used



when making fusions, the weight is 57 grams. The crucible is accurately fitted with a rigid knurled ring around its upper part, easily removable. The water-cooled German silver stopper, instead of having a rubber band to secure a tight joint, is ground into the crucible. This joint may easily be kept tight by an occasional grinding in, using for this purpose a little glass, finely ground in the agate mortar with oil.

A very good way to secure absolute tightness and, at the same time, a certain lubrication, is to melt the rubber at the extreme end of a "policeman" in the flame and apply the minutest amount possible at intervals around the upper edge of the crucible. Now in-

¹Read at the 40th General Meeting of the American Chemical Society.

²*Jour. Am. Chem. Soc.*, 21, 1899.—"Carbon Combustions in a Platinum Crucible."

³*Ibid.*, 23.—"A Spiral Crucible for Carbon Combustions."

⁴Patented 1909.

sert the stopper tightly with a turning motion. One milligram of rubber is enough for the purpose and the water circulation prevents this from being affected by the heat.

The advantages of this form of apparatus over the older form are:

1. The 60 cc. crucible weighs about 40 grams less and, on account of its simple form, it is less expensive to make.

2. When provided with an ordinary platinum cover it is a fusion crucible, on removal of the ring. Its deep form is desirable for fusions. This ready adaptability for both combustions and fusions is an advantage in any laboratory, especially the small one in which platinum is limited.

3. By doing away with the rubber band there is no risk of losing a determination in case the water supply fails temporarily.

4. The knurled ring protects the mouth of the crucible from injury and stretching, supports the crucible at the proper height in the asbestos board, and helps to secure a tight joint.

5. It is more convenient than the older form because it may be removed easily from its support for charging; this is especially advantageous in direct combustions of steel.

6. Smaller cost of repairs and renewals.

The writer, nearly ten years ago, tried nickel in place of platinum, but found it more expensive in the long run and otherwise less desirable. It is estimated that one carbon combustion in a 60 cc. platinum crucible costs about $\frac{1}{3}$ of one cent for platinum, counting interest on the investment, repairs and final scrapping. The short life of a nickel crucible makes each combustion cost about 3 cents in nickel, with risks of faulty results toward the end of the life of the crucible.

The train for carbon determination is as follows:

1. The oxygen tank. 2. KOH bulbs. 3. A small guard bulb. 4. The crucible. 5. The burner. 6. A water-jacketed brass CuO tube. 7. The zinc tube according to Johnson. 8. Calcium chloride tube. 9. Soda-lime U-tube or other absorbent. 10. A small guard tube of CaCl_2 . 11. An empty bottle provided with inlet and outlet tubes, the latter dipping under the surface of water contained in a small beaker for the purpose of noting the rate of flow of oxygen in direct combustions. The CuO tube is used only when making carbon determinations by the solution method and for organic combustions; for direct combustion of steel it is not needed. As a source of heat, a good Bunsen burner with a hot "roaring" flame is sufficient for most purposes. In many combustions, however, the upright blast lamp is necessary. For absorbent, a soda-lime U-tube weighing, when filled, anywhere from 50 to 100 grams, is used. The soda-lime should be about 20-mesh in size and free from powder.

Drillings of steel for direct combustion should be thin and should be between 20 and 60-mesh in size.

As a base for the drillings a great many substances have been proposed and the writer has tried most of them, among them sesquioxide of iron both in the form of rich hematite ore and chemically pure sesquioxide. With the latter good results may be obtained, but it is rather hard to get it reliably free from "blank." Very satisfactory results may be obtained by using sea sand previously washed and well ignited. The grains are rounded; it holds the fused oxide well and leaves the crucible clean.

In charging the crucible, put in not less than $\frac{1}{4}$ inch deep of the sand, hollow out a little depression and pour the drillings into the middle of it through a funnel with wide and short stem. Cover the drillings with a mixture of finely divided ignited asbestos and powdered CuO. One-half the factor weight—1.3635 gram—is the usual weight of steel used. Combustion should be active in from 1 to 3 minutes and should be complete in 20 minutes or less.

Carbon in pig iron may be determined by direct combustion on the sand, without admixture, but it is best to use the blast lamp. When red lead is used it is, of course, necessary to use a porcelain crucible, with sand, inside the platinum crucible.

In determining carbon in ferro-chrome, very good results were attained by burning on the sand a very intimate mixture (mixed on glazed paper with spatula) of 0.6818 gram of the finely ground ferro-chrome with four times its weight of powdered CuO.

A little experience and observation will soon indicate the best way to make direct combustions in the various steels and alloys, but it is always best to avoid coarse or thick drillings and brittle alloys should be finely pulverized. It is always well, when in any doubt as to the completeness of the combustion, to examine the fused mass for metallic particles by grinding in a mortar.

A few results follow:

	By solution and combustion.	By direct combustion.
	0.137	0.137
	0.240	0.239
	0.424	0.420
Straight steels.....	0.600	0.603
	0.829	0.823
	1.036	1.035
	0.627	0.628
	0.452	0.456
Pig iron.....	3.62	3.64
—By direct combustion.—		
Ferro-chrome	7.00	7.10 7.12
Alloy steel—W, Cr, V.....	0.00	0.450 0.444
Alloy steel—Ni, Cr, V.....	0.00	0.920 0.916
Alloy steel—Ni, Cr, V.....	0.00	0.660 0.666
Alloy steel—W, Cr, V.....	0.00	0.542 0.550
Alloy steel—Ni, Cr.....	0.00	0.194 0.196
Alloy steel—Cr, V.....	0.00	0.998 1.000

THE ANALYSIS OF SOAP.

Water.—Cut a slice of soap from the middle of the bar and reduce to very fine shavings. Weigh¹ from 8 to 10 grams of these between watch-glasses and heat in an air-bath at first at from 60° to 70° C., and then from 100° to 115° C. to a constant weight. The loss represents water together with other volatile constituents such as alcohol and essential oils which may be present.

Unsaponified Matter.—Brush the dried soap into a fat-free extraction thimble or a plaited filter-paper previously extracted with petroleum ether. Place² the whole in a Soxhlet or other form of extraction apparatus and extract with petroleum ether, which should boil below 80° C. and should leave no residue on evaporation. When the extraction is complete distill off the petroleum ether, dry the residue at 100° C. and weigh as "unsaponified matter." If waxes are present in the soap, the dried sample should be extracted with toluene since this is a better solvent for waxes than petroleum ether. In a boiled well-made laundry soap there should be no unsaponified matter unless the same has been subsequently added.

Insoluble Mineral Matter.—After extraction the contents of the thimble are dissolved in hot water. If an appreciable residue is left, allow to settle, filter, wash the residue by decantation with hot water, dry, ignite at a low temperature, and weigh as insoluble mineral matter. In a "scouring soap" this will probably consist of sand or talc.

Fatty Acids.—To the aqueous solution add a measured excess of semi-normal sulphuric acid. The fatty acids are liberated and rise to the surface. Cool the beaker with ice-water. When the free fatty acids have solidified, decant the solution, remelt the acids with hot water to remove any enclosed mineral acids, cool, filter through a wet plaited filter, and wash with cold water until the washings are no longer acid. Place³ the funnel and filter in a small beaker and heat in an air-bath. As the filter dries, the fatty acids pass through into the beaker, leaving any impurities such as silicic acid, talc, etc., behind upon the filter. Wash the filter with hot petroleum ether, distill off this latter and weigh the fatty acids. The weight obtained multiplied by 0.97 gives the weight of fatty anhydrides.

To the filtrate from the fatty acids add a few drops of methylorange and titrate with semi-normal potassium hydroxide. The difference between the number of cubic centimeters of semi-normal sulphuric acid added and the number of cubic centimeters of semi-normal potassium hydroxide required multiplied by 0.0155 will give the sodium oxide, Na₂O, or total alkali. If the soap under examination is a soft soap multiply by 0.0235 instead of the factor given above,

the result will be potassium oxide, K₂O, or total alkali.

Free Alkali.—Weigh out a separate sample extract with neutral alcohol in an extraction apparatus and determine the free alkali in the alcoholic filtrate by adding phenolphthalein and titrating with semi-normal hydrochloric acid. If the soap contains unsaponified matter, first dry the sample in an atmosphere free from carbon dioxide, extract the unsaponified matter with petroleum ether and finally extract the portion insoluble in the petroleum ether with alcohol and determine the free alkali in the alcoholic solution as before.

Combined Alkali.—The difference between the percentage of free alkali, NaOH, and the total alkali, Na₂O, will give the combined alkali. Calculate the NaOH to NaO by multiplying by 0.775, however, before making the subtraction.

If any of the alkali is present as carbonate, dissolve the residue in the extraction thimble in hot water and titrate with standard acid. Multiply the percentage of sodium carbonate found by 0.585 and deduct this also from the total alkali for the percentage of combined alkali.

Resin.—Where the soap contains resin, this may be determined by the method of V. Hübl and Stadler⁴, which is as follows:

Heat from 0.5 to 1.0 gram of the mixture of fatty and resin acids obtained above in a closed flask on a water-bath with about 20 cc. of alcohol until solution is complete. Neutralize the acids with alkali using phenolphthalein as an indicator. Pour the alcoholic soap solution into a beaker, rinse the flask with water, dilute the solution to 200 cc. and add silver nitrate to complete precipitation. Protect the precipitate from the sunlight, filter off, wash with water, dry at 100° C., and extract in a Soxhlet tube with ether. The silver resinsates dissolve in ether. The silver salts of the fatty acids do not. The ethereal solution, as it leaves the extraction tube, should be yellow or light brown in color, not dark brown. Filter it, if necessary, and shake the filtrate with hydrochloric acid in a separatory funnel. Filter the resulting ethereal solution of the resin acids from the silver chloride, wash with water, and rinse the filter and separate with ether. Distill off this latter and dry the residue at 100° C. As the resin is weighed in the hydrated form, multiply its weight by the factor 0.9732 to obtain the weight of the anhydride.

Twitchell's method is described by Divine⁵ as follows: Three grams of dry fatty acids to be tested for rosin content are weighed into a dry stoppered 100 cc. flask, dissolved in 25 cc. absolute alcohol, the flask placed in cold water, 25 cc. saturated alcoholic hydrochloric acid added, allowed to stand 20 minutes, 10 grams dry granular zinc chloride added and mixed by swirling, flask cooled and allowed to stand 20 minutes longer, contents of flask now poured into about 200 cc. water in a 500 cc. beaker, flask rinsed with weak alcohol, a small stick of zinc added, beaker covered and

¹Loewe: Fresenius' Ztschr., 19, 112.

²Allen's "Commercial Organic Analysis," Vol. II.

³Allen's "Commercial Organic Analysis," Vol. II.

⁴Benedikt's "Analyse der Fette, Wachstern," p. 125.

⁵R. E. Divine, Chem. Eng., 1, 4, 208.

heated on wire gauze until alcohol is removed, cooled, esters and rosin acids transferred to a separating funnel with ether, ethereal layer washed with water until free from hydrochloric acid, ether distilled off, esters and rosin acids dissolved in neutral alcohol and titrated with N/10 alkali and phenolphthalein. The zinc causes a brisk evolution of hydrogen and prevents bumping of the liquid while heating to drive off alcohol. The volume of water should not decrease below 100 cc.

Absolute alcohol may be conveniently saturated with hydrochloric acid by evolving the gas in a two-liter round bottom flask, containing about 1/6 its capacity of coarse granular salt such as is ordinarily used in the soap kettle, placed on a sand bath, provided with a separating funnel for introducing 60° Bé. sulphuric acid. The gas is washed in strong sulphuric acid and the alcohol is contained in a one-liter Dreschell wash bottle (allowing plenty of room for increase of volume) setting in a vessel through which a stream of cold water enters near the bottom and passes out near the top. After cautiously adding the sulphuric acid a very small flame may be used to warm the flask. Too rapid heating will cause the contents to foam over. The gas should be evolved at such a rate that the bubbles may be counted. The gas is absorbed with great avidity by the alcohol and much heat evolved. The saturated solution should be kept in a strong bottle in a cool place and caution always used in removing the stopper.

REFERENCES.

"Commercial Organic Analysis," by A. H. Allen, Vol. II. Philadelphia, Pa. Blackiston's Son & Co., 1900.

"Chemical Technology and Analysis of Oils, Fats and Waxes," by J. Lewkowitsch. London. The Macmillan Co., 1904.

"American Soaps and Candles," L. L. Lambon. New York. D. Van Nostrand Co., 1906.

"The Analysis of Soaps," J. F. Schnaible. *J. Anal. Chem.*, 4, 147.

"Notes on the Chemistry of Soap," C. R. Alder Wright and C. Thompson. *J. Soc. Chem. Ind.*, 4, 625.

"Papers upon Industrial Chemistry," A. R. Leeds. *Chemical News*, 48, 50, 67, 166.

"A New Method for the Determination of Soda in Soap, Together with a Few Notes on the Methods Generally Employed," Wilson H. Low. *J. Anal. Appl. Chem.*, 6, 423.

"The Estimation of Combined Alkali in Soaps," J. Arthur Wilson. *Chem. News*, 64, 205.

"The Determination of Water and Free Fatty Matter in Soap," J. Arthur Wilson. *Chem. News*, 66, 200. *J. Anal. Appl. Chem.*, 6, 609.

"The Separation of Resin from Fatty Acids," J. Arthur Wilson. *Chem. News*, 64, 204.

"Analysis of Washing Powders," F. P. Dunnigton, W. J. Kinney and W. H. Wenger. *Am. Chem. J.*, 14, 623.

"A Method for Determining Free Alkali in Soaps," R. E. Divine. *J. Am. Chem. Soc.*, 22, 693.

A SYSTEM OF STANDARD SOLUTIONS.*

WALTER J. ROSE.

The methods of quantitative chemical analysis may be divided into two great classes—gravimetric and volumetric. Though originally, no doubt, all methods were gravimetric, at present those of the second class are by far the more generally employed in inorganic work, being usually simpler and no less accurate. For instance, in an analysis of an ore such as the Broken Hill, involving the determination of a dozen different elements (Zn, Pb, Fe, S, Ca, Mn, F, Na, Cu, SiO₂, Al₂O₃, Ag), only one is necessarily estimated by a gravimetric method—Si. For the rest, good volumetric methods are available, which, except in the case of four, are undoubtedly superior to the gravimetric.

Volumetric methods are thus classified by Mohr (to quote from Sutton's "Volumetric Analysis"): (1) Where the determination of the substance is effected by saturation with another substance of opposite properties—e. g., acidimetry. (2) Where the determination is affected by a reducing or oxidizing agent of known power—e. g., titration with KMnO₄; Na₂S₂O₃, etc. (3) Where the determination is effected by precipitating it in an insoluble and definite combination, by a precipitant of known strength—e. g., estimation of Cl by silver nitrate. To these may be added—(4) Where the determination is effected by the measurement of the gaseous volume of the substance or of its equivalent—e. g., blue gas analysis. For the performance of the methods of the first three classes "standard solutions" are necessary. These may be defined as "solutions whose value in a certain property is definitely known"—e. g., the acidity of an HCl solution, or the amount of zinc precipitated by a K₄FeCy₆ solution. The correct determination of this value is more important than any other step in an estimation, as a wrongly standardized solution will affect the result of many assays. Every chemical laboratory engaged in analytical work uses, among others, the following standard solutions: HCl and other acids, including oxalic; KOH and other alkalis; KMnO₄; K₂Cr₂O₇; Na₂S₂O₃, and it is with the subject of the standardization of these solutions that I wish to deal.

First, to review the ordinary methods of standardization. Sutton, the leading authority on volumetric analysis, recommends the following: (1) HCl and other acids. Make up a solution of approximately the correct strength, and standardize it accurately by one of two methods—(a) Take a known weight of chemically pure and perfectly dry sodium carbonate, prepared by heating sodium bicarbonate, dissolve in water and titrate with the solution, using methyl orange as

*Paper read before the Scientific Society of Broken Hill

an indicator; or (b), in the case of a solution of chemically pure sulphuric acid, accurately determine the specific gravity of the solution, and refer to tables for its strength. Of course, once one standard acid solution is made, any alkaline solution may be standardized, and from that any other acid solution. (2) KMnO_4 .—Prepare or buy either chemically pure KMnO_4 , pure ferrous sulphate, ferrous ammonium sulphate, or pure sodium oxalate. The use of an oxalic acid solution previously standardized by means of a standard alkali is mentioned, and to this I will refer later. (3) $\text{K}_2\text{Cr}_2\text{O}_7$.—Prepare the salt chemically pure, or prepare pure ferrous chloride. (4) Prepare pure iodine, pure dry $\text{Na}_2\text{S}_2\text{O}_3$, pure As_2O_3 , or pure BaS_2O_3 .

To all these methods I have one objection—they all depend on a chemically pure reagent, and I am satisfied that such reagents cannot be accepted without question on any maker's guarantee. Of course, one may prepare pure reagents for himself, but one rarely has time for that in a technical laboratory.

The following system of standardization has been evolved in my laboratory, and makes no claim to be original. Throughout the strengths of solutions are referred to the "normal" (i. e., the gram equivalent of the substance in question dissolved in 1 litre of water), as there is no doubt that this system is most convenient where one solution may be used for the determinations of more than one substance.

Of course, in volumetric analysis there must be at least one substance that can be regarded as chemically pure, and this is found in Iceland spar—the purest form of calcite. Selected fragments of this mineral, perfectly colorless and transparent, may be depended on as absolutely pure CaCO_3 .

The best method of using this substance in the standardization of acids is due to Prof. Orme Masson of the Melbourne University. As this method seems much less widely known than it deserves, perhaps I shall be pardoned if I describe it rather fully. I quote principally from Masson's own description of the method, in a paper read before the Society of Chemical Industry of Victoria. Small, compact fragments of spar of about 1 gm. weight each are first rinsed with dilute HCl to round off corners and remove any adhering dust, and then washed with distilled water. Two or three pieces are then placed in a clean beaker, and dried on a hot plate at as near 100°C . as possible. The beaker and spar are then weighed together.

Next, 20 cc. of an approximately normal solution of HCl are run in from an accurately calibrated burette, keeping the beaker covered with a watch-glass as much as possible, to prevent loss of acid through spitting.

Allow the assay to stand for two or three hours in a cool place, then wash down the cover and sides of the beaker with a fine wash bottle jet, replace the cover and allow to boil gently on a hot plate for an hour.

Next pour off the liquid, wash the beaker and spar thoroughly with distilled water, dry at 100° and weigh.

The loss of weight is, of course, proportional to the acid contained in 20 cc. of the solution, and as the molecular weight of CaCO_3 is exactly 100, the loss in weight in gms. gives the normality of the solution.

The author claims the following advantages for the method: (1) The purity of Iceland spar and ease of obtaining it; (2) the simplicity of apparatus and ease of manipulation. Only one fluid measurement and two weighings are involved, and the whole process is carried out in one vessel, and involves only about a quarter of an hour's actual attention. Speaking from some years' experience of the method, I can say that if due care is exercised in the selection of the pieces of spar, duplicate tests will not vary by more than $2/10$ or $3/10$ of a mg. My own experience is that this method is by far the best for standardizing HCl. With this standard HCl we can now prepare a standard KOH, and then a standard H_2SO_4 . This last solution is extremely stable, and if properly kept may be relied on as unaltered for months.

The standard alkali is next used to standardize on oxalic solution, using phenol-phthalein indicator. This solution is also very stable if kept in the dark.

This oxalic solution is then used to standardize a KMnO_4 solution, and the link between Classes I and II of volumetric methods is thus made. The next step is to standardize a $\text{Na}_2\text{S}_2\text{O}_3$ solution, and that is done as follows: 5 cc. of strong H_2SO_4 are placed in a 250 cc. glass-stoppered flask and diluted with about 100 cc. of distilled water. When cool, 10 cc. of $N/10$ KMnO_4 are carefully measured into the flask, and about $1/2$ gm. of KI is added. After standing for 10 min., the iodine liberated is titrated with the $\text{Na}_2\text{S}_2\text{O}_3$ solution, using starch indicator. A $\text{K}_2\text{Cr}_2\text{O}_7$ solution may now be standardized in exactly the same way from the thio-sulphate. This solution is also extremely stable, and I have known one keep its strength for four months. From the solutions thus standardized any other acid, alkaline, oxidizing or reducing solution may be standardized.

Connection may also be made with Class III by standardizing an AgNO_3 solution by a known quantity of standard HCl, neutralized with an excess of thoroughly washed precipitated chalk, using potassium chromate as an indicator.

This system has the advantage that all the solutions so standardized are strictly consistent. All are referred to the Iceland spar—the only reliable standard of purity easily and cheaply obtainable—by a chain of the simplest of chemical estimations. This seems to me to have a great advantage over the system whereby the HCl is referred to one standard of chemical purity (and that not absolutely reliable), and the KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ to another. If accurately calibrated measuring instruments are used, and each estimation repeated two or three times, I do

not think there will be any danger of a cumulative error creeping in.

Of course, it is as unnecessary as it would be tedious to go through the whole chain every time one wished to standardize, say, the KMnO_4 solution. The sulphuric acid, oxalic acid and bichromate solutions may, as stated above, be depended on for months, and all other solutions can be quickly and accurately referred to one of them. The Iceland spar standardization of HCl , though it takes about four hours to carry through, involves only about a quarter of an hour's actual attention, and the rest of the chain can be carried out in a couple of hours. In a laboratory where these solutions are in constant use, a monthly verification of the three above-mentioned stable solutions should be sufficient. It is a good plan to keep three bottles containing these solutions for standardization purposes only, not using them for determinations, so that all working solutions made up during the month may be referred to the same standard.

The following table, representing an actual test, will serve to illustrate the system.

20 cc. HCl	= 0.9977 gm. CaCO_3 ;	HCl	= 0.9977E
5 cc. HCl	= 46.7 cc. KOH ;	HOH	= 0.1068E
5 cc. $\text{H}_2\text{C}_2\text{O}_4$	= 47.4 cc. KOH ;	$\text{H}_2\text{C}_2\text{O}_4$	= 1.0125E
5 cc. $\text{H}_2\text{C}_2\text{O}_4$	= 43.6 cc. KMnO_4 ;	KMnO_4	= 0.1160E
10 cc. KMnO_4	= 11.25 cc. $\text{Na}_2\text{S}_2\text{O}_3$;	$\text{Na}_2\text{S}_2\text{O}_3$	= 0.1031E
20 cc. $\text{K}_2\text{Cr}_2\text{O}_7$	= 8.1 cc. $\text{Na}_2\text{S}_2\text{O}_3$;	$\text{K}_2\text{Cr}_2\text{O}_7$	= 0.0418E

.0503 gm. Johnston's purest iron wire claimed to be 99.6% Fe = 21.1 cc. $\text{K}_2\text{Cr}_2\text{O}_7$... $\text{K}_2\text{Cr}_2\text{O}_7$ = 0.415E — an exact check.

The HCl was also standardized with 1 gm. of Merck's "extra pure" potassium carbonate that had been heated till quite dry. This took 14.4 cc., giving a standard of 0.9936 for the HCl . This shows the superiority of the Iceland spar method, as another drop of acid only would have been required to give the same standard, and I, for one, would not care to swear that any titration of a carbonate with methyl orange indicator is correct to one drop.

TURPENTINE FROM WOOD.

A plant in operation for the past two years in Vancouver, in which experiments have been carried on to demonstrate the practicability of obtaining turpentine from the resinous woods of British Columbia by an electrical process of distillation, has proved the possibilities of the process. It is claimed that from one cord of pitchy wood, costing \$5, there can be extracted chemically pure turpentine, tar oil, rosin, charcoal and pitch to the aggregate value of \$24.70, the present market value of these commodities, at an expense of \$12, giving returns of \$12.70 per cord. From one cord of wood by this process is obtained 60 lbs. of rosin, 20 gals. of tar oil, and 1,300 lbs. of charcoal. The amount of turpentine obtained has not been given out. The oil is used for wood preservative, and is also manufactured into shingle stain. The charcoal, having been coked, is cooled in an air-tight can, is very perfect and valuable for making powder.

USES OF SELENIUM.

The greatest use of selenium is probably in glass, to which it gives a red color. This property is utilized both merely to overcome the green color of glass and also to give it a distinct red color, such as that of the glass used on railroads for signal lights. Selenite of soda is used to give a bright-red color to enamels used for covering steel. Selenium has the property of being a very poor conductor of electricity in the dark and a fairly good conductor in the light, and a number of electrical inventions depend on this peculiarity. Selenium has been used in instruments for measuring the Roentgen rays used in therapeutic applications; in automatic lighting and extinguishing gas buoys; and the statement is frequently made that it is used in Wheatstone bridges. It has been used in experiments in telephoning along a ray of light, and for transmitting sounds and photographs or other pictures to a distance by means of a telephone or telegraph wire. Selenium cells for measuring the intensity of light have been constructed, and one such, made by coating a mica plate wrapped with platinum wire, is described by F. W. Huels.

Sulphate of ammonia, which is a grayish white crystal, containing about 25 per cent of ammonia, is largely used as a fertilizer, and also somewhat for the manufacture of anhydrous ammonia. In Europe the use of sulphate of ammonia as a fertilizer has been very greatly developed, partly by active educational methods, bringing home to the farmer the great gains from its use. It divides with nitrate of soda the responsibility for the great sugar beet crops of continental Europe, and a great deal of study has been given to the intelligent application of this most available form of nitrogen to the varying crop conditions there found. In America the development of the use of sulphate of ammonia as a fertilizer has only begun.

Coke from byproduct or retort ovens differs in some respects from that made in beehive ovens. On account of its being quenched outside of the oven it has lost the silvery glaze seen on the beehive coke. Formerly this was thought to be of some importance, as the glaze was supposed to help resist the action of carbonic acid on the coke in the blast furnace. Repeated experiments, however, have shown that the retort coke is rather more resistant to carbonic acid than beehive coke made from the same coal.

Recently silica brick has been introduced somewhat generally in coke oven construction, notwithstanding the additional complication of its considerable expansion under the temperatures of the oven chamber. Silica has the advantage of not being injured by the higher heats required by latest practice, and it is also a materially better conductor of heat than the quartzite. Magnesite is very attractive on account of its high conductivity, but it has not yet been successfully used.

METALLURGY.

TANTALUM AND ITS INDUSTRIAL APPLICATIONS.*

By ALEXANDER SIEMENS.

When the announcement was made in the year 1878 that "the division of the electric light had been successfully accomplished," many people believed that the days of lighting by gas had come to an end, and acted accordingly, much to their own disadvantage; for the competition of the glow-lamp served only to stimulate its rival to new life.

Burners of improved construction, regenerative burners, and finally gas mantles, helped to restore to gas the ground it had lost, and until a short time ago even threatened to check the spreading of electric lighting.

Not only this growing competition of gas, but the universal necessity of cheapening the production of commodities that are for general use, forced electric engineers to study in all aspects the question of improving the efficiency of electric lighting.

As a guide in their researches, they had the well-known principle that the illuminating power of a solid body increases at a much greater ratio than its temperature, or, in other words, that with the increase of temperature a greater percentage of the energy expended for heating the body is converted into light.

There is plenty of room for improvement; for even the most economical source of light, the electric arc lamp, converts only about 1 per cent of the energy of the electric current flowing through it into light, the rest appearing as heat, so that in reality all methods of lighting devised by men are, to a much greater extent, methods of heating.

The first successful incandescent lamp consisted of a carbon filament; and for a long time carbon appeared to be the only suitable substance, although the temperature to which such a filament can be raised is limited to about 1600° C., as above this point the carbon begins to disintegrate rapidly.

At this temperature the lamp consumes from three to three and a half watts per candlepower, while any attempt to produce light more economically by raising the temperature of the filament results only in shortening its life, and destroying thereby its power of competing with gas lighting.

An improvement on this result was introduced by Prof. Nernst, of Göttingen, who suggested as the source of light refractory earths, similar in character to those used for gas mantles, which, however, conduct electricity only when they are hot.

Lamps constructed on Prof. Nernst's principle have therefore to be fitted with contrivances for heating their filaments when starting, which complicate the construction of the lamp.

Another step forward was made by the invention of the osmium lamp, which is produced in a somewhat similar manner to the carbon lamp, by squirting a plastic mixture of metallic oxide and a reducing agent into the shape of a filament, which is gradually heated in a glass bulb by the passage of an electric current, while the bulb is being exhausted by an air-pump or an equivalent device.

As far as utilization of energy goes, these lamps are a great improvement on carbon lamps, but their filaments are very brittle; and the total production of osmium per year is only about 8 kg. for the whole world, of which 5 kg. are wanted for medical purposes.

In January, 1905, Dr. W. von Bolton, the head of the chemical laboratory of the firm of Siemens and Halske, announced in a lecture to the Elektrotechnische Verein of Berlin, that he had succeeded in producing pure tantalum, and his discourse was followed by Dr. O. Feuerlein, describing how tantalum had been utilized for filaments in the lamp-works of the firm.

These discourses presented the result of long years of research work, based on the general principle already alluded to, that that filament would give the best economical results which could be maintained for the longest time at the highest temperature.

The number of substances capable of conducting electricity and of sustaining such high temperatures is very limited, and platinum, the most refractory of the well-known metals, had been tried and found wanting.

It became therefore necessary to start the research by devising methods for producing the rare metals in a commercially possible manner, and then try one after the other as filaments of incandescent lamps.

While working on these lines, Dr. von Bolton succeeded, in the first instance, in producing a vanadium filament by heating a mixture of vanadium pentoxide and paraffin to 1700° C., and thereby producing sticks of vanadium trioxide, which in their turn were heated by electric currents in a glass bulb exhausted by an air-pump, and so converted into metallic filaments.

As it was found that vanadium melts at about 1680° C., such filaments were no improvement on carbon filaments; and the next substance to be investigated was niobium, which belongs to the same group of elements, but has nearly double the atomic weight.

Treated in a similar manner, the niobium filament gave somewhat better results, but still its melting-point, estimated at 1950° C., was too low for practical purposes.

*A Discourse delivered before the Royal Institution, April 23, 1909.

In this connection it should not be forgotten that, at a temperature considerably below their melting-point, all these metals begin either to soften or to disintegrate, so that their "working" temperature is not identical with their melting temperature.

Turning his attention to tantalum, which has an atomic weight of 181, Dr. von Bolton experimented with the black metallic powder produced by the method of Berzelius and Rose, and found that it could be rolled into a fairly coherent mass in the form of ribbons.

Alternative experiments, conducted on the lines by which vanadium and niobium had been obtained, resulted in the production of pure tantalum in the form of a metallic button, which was found to be tough and malleable like steel.

These and other qualities convinced Dr. von Bolton that nobody before him had handled pure tantalum, although Berzelius had first obtained the metal by a chemical process in 1824, and later Moissan succeeded, in 1902, in producing it in his electric furnace.

The latter describes tantalum as a hard, brittle metal of the specific gravity of 12.8 and a non-conductor of electricity, but he adds that the substance obtained by him contained about a half per cent of carbon.

Considering the high atomic weight of tantalum, this admixture of carbon evidently exercises a great influence on the physical qualities of tantalum, and explains the differences between the observations of Dr. von Bolton and those of his predecessors.

In nature ores containing tantalum are found in many places, principally in Scandinavia, North America, Southwest Africa, and Western Australia.

A specimen of columbite from South Dakota and another of tantalite from Western Australia are exhibited.

The columbite contains from 10 to 40 per cent of tantalum pentoxide, Ta_2O_5 , and a good deal of niobium combined with iron and manganese in various proportions.

As the separation of tantalum and niobium is somewhat troublesome, it is preferable to utilize the tantalite, which consists almost entirely of iron and manganese combined with tantalum pentoxide.

From these ores tantalum is separated in the form of a fluoride in combination with potassium, K_2TaF_7 , and subsequently reduced by metallic potassium to the black powder already mentioned, which, however, still contains some oxide and some hydrogen.

In order further to purify the product, the powder is pressed into the form of small cylinders (one of which is on the table), which are melted in a vacuum by an electric current under certain precautions into small buttons of pure tantalum such as are exhibited.

Since the production of tantalum has been carried out on a commercial scale, it has been possible to improve many details of the process, so that the tantalum produced by it at the present time is even purer than

that shown in 1905 at the discourse of Dr. von Bolton and Dr. Feuerlein.

Some specimens of this latest tantalum have been submitted to Sir James Dewar, who has very kindly made experiments with reference to its specific heat and to its thermal conductivity.

He ascertained the specific heat by plunging small spheres of tantalum, which had been heated to the temperature of boiling water, into water of $14^\circ C.$, then transferring them to melting carbonic acid ($-78^\circ C.$), and finally to liquid air ($-183^\circ C.$), and as an average of several experiments the specific heat was found to be between—

$$\begin{aligned} 100^\circ C. \text{ and } 14^\circ C. &= 0.033 \\ 14^\circ C. \text{ and } -78^\circ C. &= 0.032 \\ -78^\circ C. \text{ and } -183^\circ C. &= 0.028 \end{aligned}$$

while Dr. von Bolton in 1905 gave the specific heat as 0.0363.

Multiplying these results by the atomic weight (181) it will be seen that Dr. von Bolton's value (6.57) is slightly higher, and Sir James Dewar's value (5.97) lower than 6.4, which, according to Dulong and Pettit, is the atomic specific heat.

By the kindness of Sir James, his experiment for showing the relative thermal conductivity of iron, copper, and tantalum can be repeated here by dropping three short rods, made of these metals, in liquid air, while their tops, above the cardboard cover, are exposed to the air of the room.

In a short time the moisture of the air condenses on the rods and freezes to a distance, which depends on the conductivity of each metal.

The results of Sir James Dewar's experiments prove tantalum to have about three-quarters the conductivity of iron and about one-eighth the conductivity of copper.

At ordinary temperatures, say, below $300^\circ C.$, pure tantalum resists the action of all acids, except fluoric acid, of all alkalis, and of moisture, so that it is an ideal material for chemical apparatus which do not require high temperatures, and for any implements which, when made of steel, are liable to rust.

It has already been stated that pure tantalum is tough and malleable, so that it can be hammered out into thin sheets or drawn into fine wire, the diameter of the filament wire being 0.03 mm., or about one-eight-hundredth of an inch: all the same, it is elastic and as hard as soft steel, and has a tensile strength of 93 kg. per square mm., which is equal to 57 tons per square inch.

This means that the filament wire is capable of supporting about 80 grms., or 2.8 ounces, as can be shown by actual experiment.

Tantalum sheet can be stamped into various shapes, and out of bars of tantalum springs can be bent, as the specimens on the table show.

Another use made of tantalum is as material for writing pens, manufactured in the usual way.

When it was first offered for this purpose, it was

found that the material could not pass the test prescribed for pens made of steel.

These are pressed by a weight of 180 grms. on writing paper, which is moving at the same speed as ordinary writing, and while 10 km. ($6\frac{1}{4}$ miles) of paper are passing the loss by abrasion must not exceed 0.7 mg. (0.01 grain).

At first the tantalum pens lost more than double the permitted weight, but it was found that slightly oxidizing the surface of the pens hardens them so much that they only lose 0.8 mg. by the 10 km. test.

By weight this is still more than permitted for steel pens, but having regard to the specific weights of the two substances, the actual volumetric abrasion of the tantalum pen is the lesser of the two.

Although only the surface of the pens had been oxidized, it was found that the rate of abrasion remained the same for the whole length of 10 km., when it was expected that this rate would increase materially after the skin of oxide had been ground off.

Advantage was taken of this circumstance when an inquiry was received from India whether it would be possible to manufacture cataract knives for oculists out of tantalum.

The qualities demanded of such a knife are that its blade should be:

1. Intensely hard, so as to be able to acquire a very sharp edge of great smoothness, and to retain this fine edge for a long time.
2. Very tough without any tendency to bend.
3. Chemically and mechanically stable, so that it can be easily sterilized and that it is not liable to rust.
4. Capable of acquiring a high polish.

Manufacturing such a blade out of pure tantalum and slightly oxidizing it, before polishing it, appears to fulfil these stringent conditions, but as the knife which is on the table has not yet been actually tried for an operation, it can only serve to demonstrate the similarity of tantalum to steel for such purposes.

Another field for the application of tantalum may be found in the supply of dental instruments, owing to its immunity from chemical changes, but beyond showing two cases of such appliances, there is no necessity to go further into details.

While possessing all these qualities of a true metal, tantalum has some others which rather limit its usefulness.

When heated to a dull red it absorbs gases greedily, especially hydrogen and nitrogen, and by combining with them it loses its tensile strength and becomes brittle.

Here are three pieces of tantalum wire taken from the same coil; one of them has been heated in an atmosphere of nitrogen, the other in hydrogen, and the third has not been interfered with. The consequence is that the latter has retained its strength, while the former have become brittle and useless.

On heating tantalum in air, it shows first a yellow and then a blue tint like steel, but when the heating is continued it burns to pentoxide.

The black powder and thin wires can even be lighted by applying a match to them, as the experiment shows.

Its melting-point, *in vacuo*, lies between 2250° C. and 2300° C., which makes it particularly suitable for electrodes in vacuum-tubes, especially as it does not disintegrate—for example, Ta electrodes are extensively used in Röntgen tubes—and its specific weight is 16.6.

Turning now to the electrical qualities of tantalum, its specific resistance was stated by Dr. von Bolton, in 1905, to be on the average 0.165, with a temperature coefficient of 3 per cent between 0° and 100° Celsius.

Further experiments conducted by Dr. Pirani in the laboratory of Siemens and Halske revealed the fact that wires of various thicknesses varied in their specific resistance from 0.173 to 0.188; but after they have been heated to 1900° Celsius in a high vacuum for from 100 to 200 hours, they all possessed the same specific resistance, viz., 0.146, and their temperature coefficient between 0° and 100° Celsius had risen to 0.33 per cent.

As a temperature of the tantalum filament, when consuming 1.5 watt per candlepower, is about 1850° C., and its resistance about six times its resistance at 100° C., the temperature coefficient between 100° and 1850° C. may be taken, on the average, as 0.29 per cent.

No doubt the difference between these results is caused by alterations in the structure of the wires during their manufacture, and the heating *in vacuo* served a similar purpose to the annealing of steel, so that Dr. Pirani's results published in 1907 may be taken as standards.

At present the most important industrial application of tantalum is its use for the filaments of incandescent lamps, which may be said to date from July, 1903, when Dr. Feuerlein had succeeded in producing a tantalum wire one-twentieth of a mm. in diameter. Of this wire he made a glow-lamp with a filament 54 mm. long, using a current of 9 volts 0.58 ampere, and giving a light of 3.5 candles (Hefner), at the rate of 1.5 watt per candlepower.

A simple calculation shows that for a current of 110 volts, 660 mm. of the same wire would be required, giving at the same rate of consumption of energy a light of 43 candles.

In carbon lamps for 220 volts the length of filament is only 400 mm., and the filaments remain hard until they disintegrate. Tantalum filaments, like other metallic filaments, soften, however, to such a degree that they cannot be used in the same shape as carbon filaments.

After trying various methods of housing the long Ta filament in a glass bulb of approximately the same dimensions as the carbon glow-lamps, the present form was arrived at during the year 1904. In this lamp, which was adopted as standard, the length of the filament was 650 mm., its diameter 0.05 mm., and its

weight 0.022 grm., so that about 45,000 of these lamps contain 1 kg. of Ta.

Since then these dimensions have been modified to a certain extent; for instance, the diameter of the filament is now only 0.03 mm., but the external shape has not been altered.

It was soon found that after burning a short time the filament underwent certain structural changes and lost its great tensile strength. Examination under a microscope revealed the fact that in about 1,000 hours the smooth cylindrical filament shows signs of capillary contraction as if the cylinder was going to break up into a series of drops, and the surface, from being dull, commences to glitter. This contraction of the filament after being heated is readily recognized by comparing a new lamp with an old one. On the stars of the new lamp the filament hangs loosely, while in the old lamp the filament is evidently in tension.

The characteristic difference between carbon filaments and tantalum filaments is shown by a diagram representing the influence of temperature on the electrical resistance of the two filaments in proportion to each other.

In order to have the differences at once shown in per cents, the normal pressure and the normal resistance of both filaments, when giving the light of 1 candle for 1.5 watt, is marked as 100, and it is immediately seen that the resistance of Ta alters directly, and that of carbon inversely as the temperature. Owing to this quality, a Ta filament is better able to resist overheating than a carbon filament, as the following experiment shows, where two lamps, one Ta and one C, burning normally at 110 volts with 1.5 watt per candlepower, are gradually exposed to higher voltages. The C lamp breaks while the Ta lamp stands up to 200 volts, the highest voltage available to-night. Of course its useful life will be shorter than at its normal voltage.

As stated at the beginning of the discourse, the primary object of all the research was to find a filament more economical in the consumption of electrical energy than the C filament, and the following experiments will show that the Ta filament is, in this respect, a great improvement on the C filament.

To begin with, a comparison can be made by burning a Ta and a C lamp under water, each being immersed in a vessel containing the same quantity of water.

Owing to the C lamp requiring more energy to give the same light as the Ta lamp, the temperature of the water in the C vessel rises quicker than in the other vessel.

Another way of showing the difference is by measuring the current taken by each of the two lamps when giving approximately the same light, or by sending the same current through both lamps in series, and noting the difference in candlepower.

In conclusion, two interesting qualities of Ta should be noted:

The first is that when a Ta filament is heated in a high vacuum it will expel any oxygen that has com-

bined with it. It is possible to detect whether a filament contains any oxide by very gradually heating it up, when the parts containing oxide will appear brighter than those consisting of pure Ta, owing to the greater electrical resistance of the oxide.

These lamps have been purposely exposed to the air while they were being exhausted and have become "spotty" in consequence, but if they are raised a little above their proper voltage and left burning for a few minutes, their filaments become quite uniform by the expulsion of the oxygen.

The second is that Ta will act as a rectifier when used in an electrolyte; that is to say, will allow of the passage of the positive current only in one direction. In the apparatus shown the positive current passes through the lamp to a Ta anode, thence to a Pt cathode, but in a very short time the Ta anode covers itself with a film of oxide which stops the current. When the current is reversed the lamp lights again and continues to burn. When an alternate current is connected to the lamp it will also continue to burn, but with reduced light.

All these experiments are intended to show the remarkable qualities of this material, and when they are fully appreciated and its limitations are properly understood, there appears to be a great field open to tantalum and its industrial applications.

EFFECT OF TITANIUM ON IRON AND STEEL

Titanium has great affinity for nitrogen, and it is now believed that the amount of nitrogen retained in steel is large and thus has an important effect upon the physical properties of the metal. Ferro titanium is, therefore, employed as a flux for cleaning iron and steel at the moment of casting or pouring from the converter, as ferro silicon and ferro manganese are employed. Sulphur and phosphorus do not appear to be reduced, but in combining with oxygen and nitrogen forming oxides and nitrides, titanium has an important action in removing impurities, forming with them a stable combination, which passes into the flux.

Thus the principal function of titanium alloy is to act as flux, and the cleansing effect results in increased solidity and purity, which have such an important influence on the mechanical structure of the steel, preventing breaking down under heavy rolling loads and reducing the wear due to abrasion which are the serious defects of ordinary bessemer rails.

In the United States a new use of infusorial earth is reported in the manufacture of records of talking machines. For this purpose it is boiled with shellac, and the resulting product has the necessary hardness to give good results.

An aluminum solder, mentioned in the *Journ. Soc. Chem. Ind.*, September 30, 1900, is made by fusing 130 grains of antimony, $\frac{1}{2}$ lb. zinc, $\frac{1}{2}$ lb. tin, and 44 grains salicylic acid.

The CHEMICAL ENGINEER

RICHARD K. MEADE, Editor.

HENRY WYSOR, Metallurgical Editor.

PUBLISHED MONTHLY BY

THE CHEMICAL ENGINEER PUBLISHING COMPANY

355 Dearborn Street, Chicago

Entered as Second Class Matter, Aug. 19, 1907, at the Post Office at Chicago, Illinois, March 3, 1879.

Subscription—United States, Cuba and Mexico \$2.00
Extra postage to Canada 25c a year; to foreign countries 50c a year.
Remittances may be made by check, draft, or money order in favor of
THE CHEMICAL ENGINEER PUBLISHING CO.

All matter connected with subscriptions or advertising should be sent to
THE CHEMICAL ENGINEER PUBLISHING CO., 355 Dearborn street, Chicago.
Anything intended for the Editorial Department should be sent directly
to the Editor, Richard K. Meade, Allentown National Bank Bldg., Allentown, Pa.

NOTES AND COMMENTS.

Owing to an oversight on our part, we failed to credit an article which we published in our last issue on "New Devices for Electrolytic Assays," by F. O. Bacon, to *The Western Chemist and Metallurgist*, in which it originally appeared. We wish, therefore, at this time, to give credit where it is due.

We have frequently copied papers from this excellent publication in order that the many valuable contributions of our western friends to applied chemistry might be made available to eastern chemists. The papers which have been read before the Western Society of Chemists and Metallurgists and published in their journal have been of the very highest order and deserving of wide publicity.

Court of Patent Appeals.

Owing to the fact that patent litigation has now become such an important part of the routine of the federal courts, a movement has been on foot for a number of years to induce Congress to establish a United States court of patent appeals. It is proposed that the new court shall have the same relation to patent litigation that the supreme court has to other actions. The bill has the support of the American Bar Association, and a committee of that organization will work to secure its passage at the next session of Congress. It is probable that this bill would have passed at the last session but for the very important measures which were under discussion at that time. The bill proposes that the court shall consist of a chief justice, who will give his entire time to the work, and four associate justices, members of other federal courts, giving part of their time. The court is to have jurisdiction in appeals from other courts relating to patents, and its practice and procedure are to be governed by the rules of the United States supreme court, with such modifications as may be deemed expedient. The constitution of the new court seems to leave nothing legally to be desired and it has the support of able and experienced patent lawyers.

In a former editorial we had something to say relative to the desirability of having our patent procedure

in the hands of able technicians and men who are familiar with the various industries of our country, the processes employed and the machinery used in them. It seems to be a pity, therefore, that in drawing up this bill, some provision was not made allowing the court to engage officially, whenever it saw fit, experts able to give it assistance on questions of fact. The judges of our courts are unquestionably learned in the law and have displayed wonderful facilities at times in unraveling intricate technical problems. At the same time, however, it will be acknowledged by all that their work could be very much lightened by the employment of able experts to aid them in their deliberations. As we have said in our former article, it is a task involving much painstaking study for men of judicial training to pass opinions, which are often purely on fact and not law, upon questions involving an expert knowledge of chemistry, physics and engineering, such as very often is possessed only by the trained specialist in a particular branch of science rather than by the profession at large.

Comparative Fineness Tests of Cement.

In order to find out what variations there would be in the fineness tests of cement on the 200-mesh sieve, a sample of cement was recently procured by Mr. Geo. J. Trombold, Chief Chemist of the Ash Grove Lime and Portland Cement Company, Chanute, Kansas, and sent to a large number of laboratories. This sample was taken from a bin containing 2,000 barrels and was divided into many parts, which were put up in such shape as to insure their arrival at destination in good condition. The samples were sent to fifteen of the most representative laboratories in the country. A letter accompanied each sample stating the purpose of the test. Twelve of the fifteen laboratories reported promptly. Their results follow:

No. 1—	85.8,	Riehle U. S. Standard.
No. 2—	86.0,	Riehle U. S. Standard.
No. 3—	86.2,	Riehle U. S. Standard.
No. 4—	86.54,	Riehle U. S. Standard.
No. 5—	84.2,	Riehle U. S. Standard.
No. 6—	86.6,	Howard-Morse Standard.
No. 7—	86.8,	Howard-Morse Standard.
No. 8—	85.8,	Riehle U. S. Standard.
No. 9—	83.3,	Riehle U. S. Standard.
No. 10—	84.1,	Riehle U. S. Standard.
No. 11—	83.8,	Riehle U. S. Standard.
No. 12—	84.0,	Riehle U. S. Standard.

The tests on the whole are unsatisfactory, and it would be hard to say just what is the fineness of the cement. The average of all the tests would be 85.25, while the majority vote would be 86.0. In one laboratory it would be 83.3, while in another it would be 86.8. One city tester reported 83.3, while the tester in another city in the same state reported 86.6.

The difference in results is caused no doubt not only by the difference in the sieves, but also by the methods of sieving; in other words, "the personal equation." In the lower extremes, no doubt, the results are com-

binations of poor sieves and improper sieving. The results obtained magnify the importance of both standard sieves and standard methods of sieving. Unfortunately both are hard to attain. The standard method of sieving is slow and most testers facilitate matters by the use of shot in the sieve to help bounce the material through, or else strike the sieve against a soft block of wood or a leather pad.

It is to be noted that the results obtained from the sieves of one manufacturer agree quite closely while those received from the sieves of another vary widely. This, of course, may be due to the sieving, but it should be sufficient to make the manufacturer in question examine closely the sieves which he sends out and assure himself that they are standard. The use of worn sieves very often also causes high results.

It is hardly necessary to say that in examining sieves it is not sufficient to merely count the number of meshes to the square inch, but that it is also necessary to measure the wire from which the sieve is made. This is seldom done as it requires the pulling apart of the sieve in order to get a strand of wire. Recently the editor's attention has been called to some cement test sieves in which the wires instead of crossing alternately, that is, passing over one wire and under the next, passed over two wires in succession. It is hardly necessary to say that this method of weaving would alter the mesh and that such sieves are not standard.

Recent Progress in Radium Extraction.

Not very long ago the custom was to divide the elements into two groups: (1) *common* and (2) *rare*. Today we find greater use for vanadium and tungsten than we do for bismuth and cobalt. Geologists tell us that titanium is widespread in its occurrence and a much more common element than mercury, for instance. As the total quantity of radium extracted, we are told, has been to date less than one-fourth pound, we will probably for some time still have to consider this element as one of the rare ones. The organization, however, of the British Radium Corporation, which has begun the erection of a large radium reduction works at Limehouse, a suburb of London, England, puts this element upon a commercial basis at least. The new enterprise is not a visionary or fraudulent scheme, but is the outcome of the difficulty that the Royal Society has experienced in getting sufficient radium for its investigations. Sir Wm. Ramsay is chief chemist and sponsor for the new corporation.

The ceremony connected with the laying of the foundation of the works of the British Radium Corporation took place on October 16th, and Lady Ramsay laid the stone. The new plant will use the process devised by Sir Wm. Ramsay, which will reduce the period of manufacture from nine months to six or seven weeks. The British Radium Corporation will treat the pitchblend ore from the tin mines of Cornwall. An interesting story is connected with this ore. Associated with the British Radium Corporation

is the St. Ives Mines, Ltd., which controls an important group of tin mines in Cornwall. One of them is the Trenwith, which in former years was a producer of copper ore. Early in the last century, so the story goes, pitchblend was found in quantity. This mineral the miners mistook for black copper. On account of this delusion there was serious friction between the mines and the smelters, and the difficulty was not cleared up until 1843, when the mineral was defined as pitchblend, after which this valuable ore was considered merely as a waste product.

A concern which has lately produced, comparatively speaking, a considerable quantity of radium, is the Imperial Austrian Radium Factory, located at St. Joachimsthal, near Carlsbad. The product of this factory to date has amounted to about 13 grams of radium chloride. The pitchblend from which this radium is extracted is taken from a worked-out silver mine about twelve miles northwest of Carlsbad. Before the thirty-years war, the mine was operated by various owners, but was abandoned when the vein of silver became exhausted. It then came into the possession of the Austrian Government, and pitchblend has been mined there during the last fifty years for the uranium it contains. This latter is used in the decoration of glass and porcelain. Yellow oxides are employed by the glass manufacturer to give a delicate yellow greenish tint to glass. The black oxides are used as a pigment in porcelain painting. At the present time about 100 men are employed in both the mine and the reduction works. The annual output of the mine is about 40,000 pounds of pitchblend.

It requires approximately ten tons of the pitchblend to yield one gram of radium bromide, which is contained in the residue after the uranium is extracted. In the process 11,000 pounds of chemicals and 110,000 pounds of water are employed. In order to obtain the radium bromide, more than a thousand crystallizations and reductions have been made at the factory. This requires from a few hours to several days each, growing more difficult the nearer the approach to the radium chloride.

The thirteen grams of radium chloride obtained have been sent to Vienna, where extensive experiments are being made to determine its merit.

As to the market value of radium, it is estimated that each gram produced at the Imperial Austrian Radium Factory has cost the government from \$45,000 to \$50,000, or more than half a million dollars for the small amount produced. Originally radium sold for \$2 a milligram. Owing to the great desire, however, on the part of scientists and others to investigate its properties and the demand created thereby, the price has steadily climbed to something like \$90 per milligram, or \$2,500,000 per oz. avoirdupois. This high price is not the result of "a combination in restraint of trade," but represents merely the expense of extracting the element from the ores in which it is contained.

Should the available supply of radium be greatly in-

creased by the British factory and the new process devised by Sir Wm. Ramsay, there is no doubt but that much scientific and practical good will result.

In speaking of the medical uses of radium, Sir Wm. Ramsay has said: "It is known already that the disease, rodent ulcer, has been cured by radium compounds. It has been tried for cancer, but so far the results are not encouraging. One case treated by radium shows improvement. That is as far as I can go.

"Radium has been found useful in skin diseases. Of course, the whole subject is just at the beginning, and the object of the Radium Institute in London and similar institutes throughout the world will be to investigate the curative power of radium more thoroughly."

It is now claimed that the curative properties of the Bohemian thermal springs are due in a measure to the radio-activity of the water. Dr. J. Knett, mineralogist of the Austrian government, has discovered radium in the crystals found in the Carlsbad thermal springs, and also in the greenish quartz at Marienbad.

Corrosion of Boilers.

The corrosion of boilers has been the subject of an investigation by Prof. C. F. Burgess of the University of Wisconsin. Prof. Burgess believes that his experiments indicate that electromotive forces are developed within boilers, due to the inequalities of temperature between the tubes and the shell, and that such electromotive forces may be large enough to cause currents which will produce appreciable corrosion within a short time. Prof. Burgess suggests that the electrolysis of important parts of the boilers might be prevented by intentionally concentrating it on some object provided for the purpose. For example, an iron bar might be substituted for one of the fire tubes of a locomotive boiler and passed through the tube sheet by an insulating packing. This could be connected to the positive pole of some source of electricity, which has its negative pole connected with the boiler shell. A very small current and electromotive force, probably not over half a volt, are considered ample to accomplish very satisfactory improvements. Prof. Burgess also indorses the well-known remedy of introducing zinc into the boiler to prevent corrosion.

Prof. Burgess apparently places little reliance on the remedy which has been suggested, of setting up polarization or something akin to this which will oppose electrolytic corrosion. Dr. A. S. Cushman has made a number of experiments upon this with some boilers in Washington, and obtained most gratifying results.

The subject of boiler corrosion is an important one, and one which may well receive the attention of these two gentlemen, both of whom are unusually well equipped to solve the problem.

Bismuth is not recovered from the ores, other than lead, which contain it. It is estimated that over 880 lbs. of bismuth are lost daily in the smoke and gases from the Washoe smelter.

BOOK REVIEWS.

A STUDY OF THE OPEN HEARTH. By Harbison-Walker Refractories Co. 17 x 10. Limp leather. Gilt. 91 pages. 1909.

As is prefatorily stated this study was made for the purpose of gaining a thorough understanding of the conditions to which open hearth refractories are subjected, thus enabling manufacturers to produce materials that will most successfully fulfill the requirements. The treatise is a good introduction to the study of open hearth practice, and while it is of special use to those connected with this branch of the steel industry, it will interest the iron and steel men at large. Naturally and properly, the materials for and the construction of open hearth furnaces are given precedence. In connection with the invention of the open hearth process the name of Martin should have been mentioned with that of Siemens. Some parts in the discussion of the process are defective from the chemical standpoint, but on the whole the text is authoritative and well written.

FORGING. By John Lord Bacon, Instructor in Forge Work, Lewis Institute, Chicago. 17 x 25. Cloth. 112 pages. 180 illustrations. Chicago, Ill., American School of Correspondence. 1909.

This is eminently a practical manual for the iron and steel worker. The book opens with a classification of the forgable varieties of iron, and following this are descriptions of the smith's tools and appliances, the general instructions concluding with special directions for heating iron in the forge. Hand forging is dealt with at considerable length, the text being copiously illustrated by drawings and figures in half-tone. Special and complete instruction is given on welding and tool steel work, including hardening, annealing and tempering. A few pages are devoted to steam hammer work, and there is another section on miscellaneous apparatus and operations in the metal worker's craft. Electric welding is discussed in the last 10 pages of the book.

In a scientific light some of the statements and methods are defective. Examples are to be found in the distinctions made between iron and steel on p. 1; the explanation of the action of welding fluxes on p. 13, and under the subject of "Tool Steel Work," pp. 60-63, no mention is made of the use of temperature indicators with the furnaces and baths used in the heat treatment of steel. As a practical guide, Mr. Bacon's book is worthy of high recommendation.

TRADE LITERATURE.

F. W. Braum, Los Angeles, Cal. Catalog B. Tools and apparatus for the physical and chemical laboratory. Chemicals. Fully illustrated. Physical and chemical tables.

Goldschmidt Thermit Company, New York. Illustrated Bulletins on "Applications of Thermit in Foundry Practice; Instructions for the Use of Thermit in Railroad Shops; Butt-Welding Wrought Iron and Steel Pipes by the Thermit Process," and "Metals and Alloys Free from Carbon Produced by the Thermit Process."

Buffalo Foundry and Machine Company, Buffalo, N. Y. Bulletins describing Vacuum Rotary Dryers. Illustrated.

Denver Fire Clay Company, Denver, Colo. Bulletins with illustrations, brief descriptions and prices of Case, Gasoline and Gas Furnaces for Assayers. Also Metallurgical Clay Goods.

Taylor Instrument Companies, Rochester, N. Y. Electrical Thermometry: Catalog illustrating and describing pyrometers of the Fery, LeChatelier and Resistance types. Also catalog illustrating and describing the "Tycos" industrial pyrometer. The company's recent literature well represents the present advancement in high temperature measurement.

HOW TO RECOGNIZE PITCHBLENDE.

Prof. Herman Flick, Director of the Colorado School of Mines, gives the following characteristics of pitchblende, the mineral from which uranium and radium are obtained.

"Pitchblende occurs in fissure veins, in igneous rocks like granite. It is valued for its uranium and radium contents. It is not found in sedimentary rocks, although alteration products of it may be found therein. Such alteration products are colored yellow or greenish, and when in sufficient concentration and quantity, are valuable for their uranium contents. The radium value in these is small, as a rule.

"Pitchblende is found in vein matter in stringers varying from knifeblade thickness to several inches. It is 'bunchy.' The associated minerals in addition to vein matter are sulphides such as zinc blende, galena, and iron pyrite. The latter usually predominates. It is detected by the following properties:

"*Color*—Pitch black, velvety black, brownish sometimes with a grayish or greenish cast. The streak on rough porcelain, i. e., the edge of a broken plate, is brownish black, olive green, or grayish.

"*Luster*—Dull, metallic, greasy, pitchlike.

"*Fracture*—Conchoidal, that is with smooth curved surfaces to uneven. Brittle.

"*Hardness*—Less than quartz. It is not scratched by a knife blade unless weathered.

"*Specific Gravity*—Heavier than iron or steel; also heavier than galena.

"The following common minerals are likely to be mistaken for pitchblende by prospectors: Obsidian or volcanic glass, which differs from pitchblende in its lightness, glassy luster and light streak. Magnetite, which differs from pitchblende mainly in that it is attracted by the magnet. Hematite, which differs from pitchblende mainly in possessing a red streak."

INDUSTRIAL NOTES.

Sauveur & Boylston, successors to Albert Sauveur, Cambridge, Mass., are issuing an attractive illustrated catalogue, descriptive of the apparatus which they handle for the metallographic laboratory. This catalogue also describes their excellent correspondence course in metallography. This course has made metallography available to a large number of iron and steel chemists who graduated from college before this valuable method of studying the constitution of metals came into general use. The course is inexpensive, and in most cases, we have no doubt, the iron and steel company would be willing both to furnish the apparatus and also pay for a course of tuition for their chemist, as the benefits which the employer would derive thereby would be more than commensurate with the cost of the course and apparatus.

William W. Winship, P. O. Box 142, Brooklyn, N. Y., is the manufacturer of Winship's Muriatic Putty, a plastic compound for chemical jointing in the presence of chlorine, muriatic acid, cyanides, etc. This putty has been found convenient for both laboratory and commercial use. It is reliable and economical and may be obtained in small quantities.

We have received from the Holtzer-Cabot Electric Co., Brookline Station, Boston, Mass., circulars describing various types of dynamos suitable for electroplating work. These dynamos are of the very best make and are wound for low voltage. They are made in sizes giving an output of from 35 to 1,400 amperes at six volts. The Holtzer-Cabot Electric Company also manufactures a small drill which would be found very convenient in laboratories for drilling samples of metal. It is portable and may be attached by a plug socket to a lamp, and consumes only about as much current as one or two incandescent lamps. The motor and table are adjustable and drills up to one-fourth of an inch may be used.

We have received from the J. T. Baker Chemical Company an attractive catalogue of their analyzed chemicals. The cover of the book contains a representation of a bottle of potassium bichromate. This is printed in colors and shows the label and the neat and attractive manner in which the J. T. Baker Chemical Co. puts up its salts. In addition to the prices, the analyses of the various chemicals are also given. Some useful data are inserted upon colored sheets. This consists of tables for making normal solutions, atomic weights, table of solubilities, specific gravities of hydrochloric, nitric and sulphuric acid and for conversion of temperature, weights and measures. The back cover contains a birdseye view of the plant. The J. T. Baker Chemical Company are also distributing monthly calendars, each of which contains a portrait of some famous chemist.

The Somet-Solvay Co., 100 William street, New York, is now making an extensive line of protective

paint for iron and steel. These paints are of the coal tar order, and were developed originally by the Semet-Solvay Company to protect their own chemical works and retort coke oven plants, where linseed oil paints had failed again and again.

Crysolite, the best known of their protective paints, has been extensively employed for use upon all forms of iron and steel. The Semet-Solvay Company also manufactures Solvay Acid-Resisting Paint, which is resistant to both acids and alkalies, and has been used extensively in chemical works. These coal tar paints also have extensive applications in other industries.

Franklin H. Kalbfleisch Co., Broadway and 16th streets, New York City, are manufacturers among other things of pure sulphuric acid, suitable for electrolytic for storage batteries. This acid is not made from pyrites but from pure brimstone. Storage battery electrolyte has been made a study of, and is a specialty with this firm. The life of a storage battery depends largely upon the electrolyte which is used. If the electrolyte is made from impure and improper material and contains arsenic, iron and other metallic and organic substances, it will destroy a battery quickly by causing chemical changes. This is an established fact, as is borne out by such distinguished authorities as Fay, Lunn, Dyndon, Machalske, Wade, and other authors of standard works upon storage batteries and their care. An electrolyte made from pure brimstone, sulphuric acid, and pure distilled water, and insures a long life to the battery and a quick and ready response to the call for power, whether in the case of the largest central station battery or the small one in use in the chemical laboratory for furnace purposes. The F. H. Kalbfleisch Company guarantee that every pound of electrolyte which they manufacture is made from pure brimstone, sulphuric acid and distilled water. They also claim that they were the first to manufacture pure electrolyte, and that in the millions of pounds that they have sold they have yet to hear of a single instance where their electrolyte has contributed in the slightest degree to the failure of a battery. This is certainly a record to be proud of.

The Davis-Bourmonville Co., 90 West street, New York City, are distributing attractive pamphlets and photographs, giving illustrations of some recent uses of their oxy-acetylene process for welding. Among these applications may be mentioned the following:

Repairing a cracked kettle weighing about 2 tons. The thickness of the cast-iron varied from 5 ins. at the bottom to 3 ins. at the rim. The weld was made in metal about 3 ins. in thickness. The crack was 18 to 19 ins. long and did not extend to the rim.

Welding steel dryers about 16 ft. long and 5 ft. in diameter, made of $\frac{1}{2}$ -in. steel. They are constantly revolved over fire, and in time sections of these lengths show imperfections. These parts can be cut out with oxy-acetylene tool and the portions yet serviceable welded together butt end. Usually out of three lengths

showing imperfections one serviceable length can be made.

Another unusual job was welding a cast steel tee 20 ins. in diameter in a trench in Philadelphia. This tee was in a pipe line and to replace it would have meant an expenditure of about \$200, besides the loss of the use of the water supply. The length of the track was about 9 ins. Attempts had been made to braze it, but these were unsuccessful. The weld was made with the oxy-acetylene torch, using the same metal as that of which the pipe was cast, to fill in with. While this operation was under way there was 4 ins. of water constantly running through the pipe which could not be shut off, owing to a strained valve.

We have received from Messrs. Mason, Fenwick and Lawrence, patent attorneys and lawyers, St. Paul Bldg., New York and Washington, D. C., a copy of a neat little pamphlet, entitled "Chemical Patents," by Mr. Hugo Mock. This little pamphlet tells how chemical patents are procured and other information concerning chemical patents in the United States and abroad. Mr. Mock is a member of the American Chemical Society and also of the Society of Chemical Industry. The pamphlet is well worth the perusal of chemists in general, and particularly of those who are of an investigating or inventive turn of mind.

RECENT INVENTIONS.

The following patents relating to industrial and engineering chemistry are reported by C. L. Parker, solicitor of chemical patents, McGill Building, 908 G. street, N. W., Washington, D. C.:

935,695. *Compound for Purifying Water.* Carl W. Schultze, Buffalo, N. Y. October 5, 1909.

This is a tablet for treating lime bearing waters which consists of an adapted unit of a soluble salt capable of forming a gelatinous precipitate, an insoluble powder of such fineness that the particles will remain suspended for a considerable length of time, and a binder.

935,796. *Production of Magnesium.* Franz Von Kugelgen, Holcombs Rock, Va., and George O. Seward, East Orange, N. J. October 5, 1909.

This is a process of obtaining magnesium by electrolyzing a magnesium salt with a cathode of a metal less electropositive than magnesium and which forms therewith an alloy of lower melting point; and subsequently dissolving the magnesium out of said alloy by using the latter as an anode with a suitable molten electrolyte and depositing the magnesium at the cathode.

935,814. *Method of De-alcoholizing Beer.* Francis J. Pribyl, Uniontown, Pa. October 5, 1909.

A method of manufacturing a non-alcoholic beverage from a carbonated beverage containing alcohol by heating the beverage, thereby liberating the carbonic-acid gas therefrom, then heating the decarbonated beverage to a temperature of 150 degrees Fahr., then removing the alcohol from the heated decarbonated beverage by spraying the same, and then incorporating carbonic-acid gas in the de-alcoholized beverage.

935,863. *Alloy and Process for Its Production.* Auguste J. Rossi, New York, N. Y. October 5, 1909.

The process consists in first making an alloy of copper with titanium, next producing an alloy of such other metal with titanium, next bringing said two last mentioned alloys

together and reducing them in each others presence, to molten state.

935,880. *Manufacture of Pure Lithium Compounds.* Erland Zell, Gottenborg, Sweden. October 5, 1909.

The process consists in manufacturing lithium compounds consisting in heating a mineral containing lithium with carbon in the presence of a volatile hydrocarbon.

935,900. *Process of Treating Zinc.* Salomon Frank, Frankfurt-on-the-Main, Germany. October 5, 1909.

The process consists in causing zinc to flow under a minimum pressure of 6000 kilograms per square centimeter and at a temperature of not more than 80 degrees centigrade.

935,942. *Process for Making Sugar.* Charles P. Stewart, Los Angeles, Cal. October 5, 1909.

The process comprising combining carbon, hydrogen and oxygen in substantially the proportions to produce C_2H_2O and then subjecting the resultant gases to magnetic influence.

936,010. *Process and Machine for Marbleizing Paper and the Like.* Heinrich Metzger, Aschaffenburg-Damm, Germany. October 5, 1909.

The process consists in causing a thin film of a readily movable liquid to flow bodily on a stationary support, applying color to the surface of said flowing film, bringing only the surface of the paper in tangential contact with the color on the moving film to transfer such color from the film to the paper, and spraying a liquid against the marbled side of the paper after it has come out of contact with the film.

936,070. *Liquor For Impregnating Wood.* Karl H. Wolman, Idaweiche, near Oppeln, Germany. October 5, 1909.

The composition consists of a compound solution of iron sulphate and raw acetate of ammonium.

936,095. *Metallurgical Process.* Oliver B. Dawson, El Paso, Texas. October 5, 1909.

This is a process of immediate reduction of ores of metal which do not form carbides, consisting in heating the ores to incandescence, subjecting the incandescent ores, at a temperature below the fusion or volatilizing point of the contained metal, to the reducing action of carbon monoxid in the absence of air and flux, then introducing granular carbon into the incandescent mass after reduction, and then heating the same to the temperature of fusion of the metal.

936,113. *Means and Method For Protecting From Decomposition and Putrefaction Vegetable Fibers, etc.* Anders Gadd and Gustaf Dillberg, Ovedsgard, near Ovedsklostersgard, Sweden. October 5, 1909.

The process consists in treating threads and fabrics with a solution of tannic acid and creolin and then treating the goods with a solution of formaldehyde.

936,203. *Paint.* Joseph A. West, Miertown, Ind. October 5, 1909.

This paint embodies in its composition coal tar, oxide of iron, slate, chipped rubber, asbestos, gasolene, asphaltum, cement, and turpentine in about the proportions of coal tar one barrel, oxide of iron fifteen pounds, slate, fifteen pounds, chipped rubber, twenty pounds, asbestos, ten pounds, gasolene, five gallons, asphaltum, five gallons, cement, fifty pounds, and turpentine, five gallons.

936,288. *Bleaching, Cleansing, and Sizing Compound.* Samuel A. Flower, New York, N. Y. October 5, 1909.

The compound comprises a hypochlorite of soda, carbonate of lime, soap and acetic acid.

938,241. *Composition for Treating Fuel.* Edward H. Ellis, Winthrop, Mass. October 5, 1909.

The composition comprises phosphoric acid, black oxide of manganese, oxallic acid, saltpeter, and sodium chloride.

936,317. *Method of Making Solid Fertilizers.* Birger F. Halvorsen, Christiania, Norway. October 12, 1909.

The method comprises dissolving phosphates in nitric acid, and adding hot calcined calcium nitrate.

936,328. *Process of Manufacturing Fermented Beverages.*

Etienne W. Kuhn, London, England. October 12, 1909.

The process consists in conducting the fermentation in a large container completely filled with liquid, raising the pressure on the liquid in said container to about 20 atms. by forcing into the container liquid of the same nature as that already contained therein in such a manner that no gas enters or is formed within the forcing device and the container, and passing an electric current through the fermenting liquid.

936,339. *Composite Metal.* Joseph G. Mellen, New York, N. Y. October 12, 1909.

The metal contains a compound of aluminum, magnesium and phosphorized copper and being characterized by its great lightness, hardness, strength and workability.

936,382. *Process of Deoxidizing Slags.* Otto Thallner, Bismarckhutte, Germany. October 12, 1909.

The process consists in deoxidizing a slag containing iron over a molten bath of steel, by forcing aluminium into the steel bath during the melting process until said steel bath is completely deoxidized and continuing the supply of aluminium to said steel bath, so that free aluminium rises to the surface of the molten steel and acts on the layer of slag from below.

936,403. *Process of Making Filaments for Electric Incandescent Lamps.* Werner Von Bolton, Charlottenburg, Germany. October 12, 1909.

The process consists in inserting refractory metal powder into a tube of ductile metal, exhausting the same of air, sealing the ends of said tube and subsequently working the tube and refractory metal into filamentary form.

936,468. *Process of Reclaiming Devulcanized Rubber.* Erwin F. A. G. Meyer, New Brunswick, N. J. October 12, 1909.

The process consists in depolymerizing devulcanized rubber by treating devulcanized rubber with a neutral resinous soap at a temperature over 120°C.

936,514. *Process of Making Composite Ships' Plates.* George C. Berg, San Francisco, Cal. October 12, 1909.

The process consists in making composite ships' plates of steel and copper by converting the surface of the steel plate with a suitable fluxing material to prevent oxidation when raised to a high temperature, then laying thereover copper of suitable thickness, then passing through the adjoining surfaces of the steel and copper a current of electricity, to generate, by resistance of the material, heat sufficient to cause the adjoining surfaces of the steel and copper to intimately commingle, then passing through said surfaces an electric current of small quantity and high voltage.

936,525. *Process of Making Metallic Films or Flakes.*

Thomas A. Edison, Llewellyn Park, Orange, N. J. October 12, 1909.

The process consists in making films or flakes of cobalt or nickel or cobalt-nickel, which consists in electrolytically depositing upon a suitable cathode a layer of film of copper, then in depositing on the copper a layer or film of cobalt or nickel or cobalt nickel, then in separating the composite sheet from the cathode and in finally dissolving the deposited copper film to free the film of cobalt or nickel or cobalt nickel.

936,530. *Permanent Magnetic Metal.* Samuel E. Gertler, New York, N. Y. October 12, 1909.

The metal comprises tungsten steel and aluminum.

936,545. *Process of Extracting Precious Metals From Ores.* Isidor Kitsee, Philadelphia, Pa. October 12, 1909.

This is a process of extracting metal from its ore consisting in subjecting said ore to the dissolving action of a chlorinated water, and a gaseous product of the electric arc.

936,555. *Process for the Manufacture of Portland Cement.* Charles F. McKenna, New York, N. Y. October 12, 1909.

The process consists in working peat, marl, and clay de-

posits by removing the individual deposits by a hydraulic extractor, admixing the washings of the marl and clay deposits, throwing the peat washings on a screen, and throwing the admixed washings of marl and clay upon the peat during the process of screening, whereby the washings of peat serve as a filter for the washings of the other deposits.

936,637. *Method of Coating Metallic Surfaces.* Charles J. Kirk, New Castle, Pa. October 12, 1909.

The method consists in sherardizing the metal to form a primary coating and then forming thereon a second metallic coating capable of uniting with the primary coating.

936,713. *Method of Plating Metals.* William Griffith, Pittsburgh, Pa. October 12, 1909.

The process consists in first cleaning the metal to be coated, coating with a suitable solution of alkali, coating the same with a metal or alloy of lower fusing point, applying a second metallic coating, and then applying in molten form, a metal that will unite with the last named metal.

936,762. *Process for the Recovery of Copper From Cuprous Residues.* Dominic Crispo, Antwerp, Belgium. October 12, 1909.

This is a process for the recovery of copper from residues containing copper in a metallic state consisting in treating those residues with dilute sulphuric acid and manganese dioxide and adding iron persulphate in sufficient quantities to act as a contact agent, whereby the dissolving of the copper present is accelerated.

936,821. *Method of Bluening Metal.* Harry E. Sheldon, Pittsburgh, Pa. October 12, 1909.

The process consists in causing a rolling pressure to progress along the surface of the sheet and heating said sheet as it so progresses to such a temperature as will produce a blue finish thereon.

936,842. *Process of Removing Paint, Varnish, and Finishes.* John M. Wilson, Montclair, N. J. October 12, 1909.

The process consists in subjecting a dried film of paint or varnish to the action of a "paint and varnish remover," capable of reacting thereon and destroying the identity of said film and its affinity for an underlying surface, and then affecting the subdivision of the resulting amorphous mass into fine shreds, while simultaneously separating the same from the said underlying surface, and while permitting of the free escape of the volatile solvents contained in said mass, whereby self-sustaining particles are obtained adapted to be readily dislodged from smooth surfaces which may be brought into contact therewith.

937,008. *Process of Preserving Wood.* John M. Nelson, Jr., Sherwood, Md. October 12, 1909.

The method consists in first subjecting the same to the action of a bath of a suitable liquid heated to a temperature of over 100°C, then to a bath of a suitable preservative liquid at a lower temperature, then to the action of a bath of a suitable liquid at a temperature at least as high as the first bath.

937,031. *Process for Smelting Ore.* Joseph P. Welch, Salt Lake City, Utah. October 12, 1909.

The process consists in subjecting a constantly falling and flowing mass of previously calcined ores to the heat of an impinging stream of burning carbon and oxygen, while said falling and flowing mass of ore is allowed to contact with fused silica.

937,095. *Sizing Composition.* Mario Rossi, Cervignano, Austria-Hungary. October 19, 1909.

The composition comprises the product resulting from the action of sulphur dioxide on starch, and a soap-like material.

937,119. *Process of Producing Silicon Carbide.* Frank J. Tonn, Niagara Falls, N. Y. October 19, 1909.

The process consists in supplying a charge of silicious and carbonaceous material, maintaining within the charge an

electric arc of sufficient heating capacity to produce silicon carbide and moving the arc zone from the formed silicon carbide in the direction of the unreduced mixture.

937,128. *Method of Oxidizing Metals Dissolved in Mercury.*

Jasper Whiting, Boston, Mass. October 19, 1909.

This is a method of oxidizing metals dissolved in mercury, which consists in providing carbon surfaces exposed to an oxidizing electrolyte and a moving body of amalgam and establishing electrical contact between the carbon and the amalgam through a relatively quiescent body of comparatively pure mercury.

937,147. *Process of Making Sulphur Trioxide.* George Eschellmann and Albert Harmuth, St. Petersburg, Russia. October 19, 1909.

The invention comprises a step in the contact process of making sulphur trioxide which consists in removing lubricating oil from the gases in transit from the gas-pump to the contact-chamber.

937,154. *Method of Removing Tarnish From Metals.* Marshall H. Key, Chicago, Ill. October 19, 1909.

The process consists in immersing the metal to be brightened in an electrolyte consisting of sodium carbonate, sodium bicarbonate, and sodium sulphate, in solution, in which is immersed a metal of a more positive electrical character, and in bringing the metal to be brightened after immersion, into electrical contact with the more positive metal.

937,210. *Process of Preparing Potable Waters.* John T. Harris, New York, N. Y. October 19, 1909.

The method consists in electrolyzing water in the presence of hydroxides of iron and aluminum and a compound of copper.

937,263. *Method of Hardening and Toughening Metal.* Henry W. Partin, Portsmouth, Va. October 19, 1909.

The method consists in treating the heated metal in a compound containing borax, soda, cobalt and common salt and then subjecting the metal to the tempering process.

937,284. *Alloy.* Edward B. Craft and Jonathan W. Harris, Hackensack, N. J. October 19, 1909.

The alloy is composed of gold, silver and platinum, in approximately the following proportions: Gold, 67½ to 70 per cent; silver, 25 per cent; platinum, 5 to 7½ per cent.

937,285. *Alloy.* The alloy is composed of gold, silver and nickel, in approximately the following proportions: Gold, 67½ to 70 per cent; silver, 25 per cent; nickel, 5 to 7½ per cent.

937,293. *Process of Obtaining Metals From Their Ores.* Alexander T. Elliott and Albert Miller, Los Angeles, Cal. October 19, 1909.

The process consists in recovering gold together with copper by subjecting the ores of said metals to the action of a solution of ferric sulphate containing sodium chloride and free chlorine thereby dissolving part or all of the gold and also dissolving the copper, drawing off the solution, precipitating the gold and copper from the solution by the action of iron, oxidizing the resulting ferrous sulphate solution to ferric sulphate in solution by the action of manganese dioxide, and regenerating said manganese dioxide by acting thereon with atmospheric air.

937,387. *Process of Recovering Precious Metals.* James H. Reid, Newark, N. J. October 19, 1909.

The method consists in mixing the comminuted ore with lead and a flux, then passing the mixture through an electric arc while exhausting the volatile products, and then rotating the molten mass to effect separation between the silver and the remaining metals.

937,486. *Process of Producing Steel Free From Protoxides.* Otto Thallner, Bismarckhütte, Germany. October 19, 1909.

The process consists in blowing the steel and passing the blown steel to a basic electric furnace, adding silicon to

said steel, heating said metal in said furnace together with the silicon till the metal and slag are deoxidized and then adding further silicon.

937,720. *Process of Tanning Skins and Hides.* Henry Dehm, Mulhausen, Germany. October 19, 1909.

The process consists in impregnating the prepared skins and hides with the solution of a basic salt of a sesquioxide, and then treating the impregnated skins and hides with an alkaline solution of sodium zincate.

937,801. *Process of Renovating, Cleansing, and Aromatizing Tobacco.* Stewart B. Heddles, Janesville, Wis. October 26, 1909.

The process consists in treating tobacco with a liquid containing formaldehyde, wines and spirits.

937,892. *Process of Preserving Wood.* Werther A. G. von Heidenstam and Karl L. F. Freidemann, Stockholm, Sweden.

The process consists in impregnating wood with a water solution of calcium cresate alone, and then subjecting the wood to the action of a gas-mixture containing carbonic acid.

937,868. *Fiber Concrete for the Construction of Fireproof Buildings.* Gustaf Rosenleaf, Grand Forks, N. D. October 26, 1909.

The concrete comprises comminuted vegetable fiber, sulphate of ammonium four pounds, sulphate of copper two pounds, lime one barrel, Portland cement and clean sand of each one and a half bushels, and water.

937,869. *Composition of Matter.* George W. Rowe and Guy A. Howard, Hampton, Va. October 26, 1909.

The material contains calcined plaster and shredded corn cobs.

937,965. *Extraction of Copper From Raw Unroasted Ores and Other Products.* Georg Schneider, Friedeburg, Germany. October 26, 1909.

The process consists in treating copper ores and other products containing copper wholly or partially in the form of sulphids by the action thereon of chlorine by causing free chlorine to be generated in the mass to be treated by adding thereto a certain amount of dioxide of manganese and treating the mixture with a solution containing hydrochloric acid of suitable strength.

938,055. *Method of Treating Poor Sulphide Ores.* Alfred Holdsworth, Barnsbury, London, England. October 26, 1909.

The process consists in mixing with the ore material, in a finely divided condition, sulphuric acid of substantially 60° Baume', in amount determined by the composition of the ore, and substantially in the proportion of one molecule of acid to each atom of sulphur present in the ore, calcining the mixture with free access of air, to decompose the unstable sulphate into oxides and to oxidize the sulphur, leaching out the stable sulphate with water, and subsequently leaching out certain of the oxides with acid.

938,128. *Neutralizing Solutions of Salts.* Bernard Diamand, Idaweiche, Oberschlesien, Germany.

This is a process of neutralizing solutions of salts for wood preserving, which consists in adding an alkali to waste sulphite liquor and mixing the resulting solution with sulphate of aluminium, sulphate of iron, and fluoride of sodium.

938,269. *Manufacture of Alumina.* Gilbert McCulloch, East St. Louis, Ill. October 26, 1909.

This is a process for the manufacture of alumina by the alkaline process, wherein the alumina is precipitated from a solution of sodium aluminate, the improvement consisting in adding to the solution after the period of precipitation caustic alkali and re-dissolving the silica precipitated with the alumina.

938,270. *Recovery of Soda in the Manufacture of Alumina.*

Harry C. Peffer, East St. Louis, Ill. Oct. 26, 1909.

The method consists in recovering soda from the red mud residuum left in the manufacture of alumina from bauxite by the alkaline process in which lime is used, by adding additional caustic lime to the red mud and digesting the mixture with water under pressure, thereby rendering the soda soluble and then filtering and separating the soda.

938,308. *Process of Producing Fermentable Sugar From Ligno-Cellulose.* Malcolm F. Ewen and George H. Tomlinson, Chicago, Ill. October 26, 1909.

The process consists in producing fermentable sugars from ligno-cellulose by placing a quantity of it in a closed vessel with not to exceed two and one-half times its weight of water, supplying to the vessel the described quantity of a strongly hydrolyzing acid such as sulfuric acid or hydrochloric acid, quickly raising the temperature of the mixture to about the described critical point, by applying steam thereto, maintaining such temperature until the re-action is completed and then quickly reducing the temperature to at least the boiling point of water.

938,374. *Process for the Production of Kvass.* Alexander Eisenberg, St. Petersburg, Russia. October 26, 1909.

The process consists in producing kvass, by preparing a suitable wort, boiling said wort to eliminate the albumen and destroy the ferments therein, adding to said wort a yeast cultivated in a culture medium corresponding to the taste desired to be obtained and adding lactic ferments which stop the alcoholic fermentation.

938,377. *Process of Uniting Metals.* William Griffith, Pittsburgh, Pa. October 26, 1909.

This is a process of uniting iron, steel, or other metal, with copper, brass or other metal or alloy, which consists in cleaning the harder metal, giving a metallic deposition by subjecting to a solution of metallic salt, and the applying in molten form a metal that will unite with the last named metal.

938,432. *Removal of Silica in the Manufacture of Alumina.* Harry C. Peffer, East St. Louis, Ill. October 26, 1909.

This is a step in the process for the manufacture of alumina in which bauxite is digested with lime and carbonate of soda to form aluminate of soda, which consists in allowing the aluminate of soda liquor to remain in contact with the red mud for a sufficient time to cause the precipitation of the silica.

938,451. *Process of Making Active Material for Storage-Battery Electrodes.* Joseph W. Aylsworth, East Orange, N. J. October 26, 1909.

This is a process of making active material for storage batteries which consists in electrolytically forming the active material in and depositing the same out of a cyanid solution thereof.

The yield of by-products from the coking of coal depends upon the grade of coal and method of operation, and will vary from 3 to 8 gals. of tar, 14 to 24 gals. of ammoniacal liquor of varying degrees Twaddell and from 2,000 to 5,000 cu. ft. of surplus gas per short ton of coal. This gas will vary in heat units and illuminating power, as a rule, in proportion to the richness and volume of the volatile matter present in the coal, as well as the temperature of distillation, weight of coal charged, duration of charge, and operation of ovens as regards rapid removal of gas, or under pressure.



TP

Chemical age

1

C32

v.9-10

~~XXXXXXXXXX~~
~~XXXXXXXXXX~~
~~XXXXXX~~

Engineering

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

ENGIN STORAGE

